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EPA ACTIONS TO CANCEL AND SUSPEND USES OF CHLORDANE AND HEPTACHLOR AS PESTICIDES

ECONOMIC AND SOCIAL IMPLICATIONS

AUGUST 1976

EPA–540/4-76-004

Criteria and Evaluation Division
Office of Pesticide Programs
U S ENVIRONMENTAL PROTECTION AGENCY
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ECONOMIC AND SOCIAL IMPLICATIONS
PART I

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Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
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PREFACE

This publication is a composite of economic and social impact studies conducted in relation to the announcements of the Administrator of EPA that he intended to cancel many of the currently registered pesticidal uses of chlordane and heptachlor (November 18, 1974; See Appendix F below for Federal Register notice) and later (July 29, 1975) that he intended to suspend these same uses (See Appendix G below for Federal Register notice of suspension).

This publication is divided into two parts:

Part I. Economic and Social Impact Analysis of Cancelling Certain Uses of Chlordane and Heptachlor.

Part II. Economic Testimony Presented by EPA at Chlordane/Heptachlor Suspension Hearings, September 18-19, 1975.

The studies presented in Part I are those conducted during the period July, 1974 - May, 1975, relative to the cancellation action for chlordane/heptachlor (hereafter collectively referred to as C/H). These studies, reported in Part I, provided information for policy review within EPA during the period and were also used in drafting the Environmental Impact Statement (EIS) on the C/H cancellation action.

Part II is the economic testimony presented at the C/H suspension hearings. It is based on the earlier studies reported in Part I, as supplemented by added information and analysis generated in connection with the suspension.

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The following scientists were the major contributors to this report:

Fred T. Arnold, Ph.D. candidate, Agricultural Economist
Arnold L. Aspelin, Ph.D., Agricultural Economist
Stewart L. Colten, M.Ch.E., Chemical Engineer
Fred Hageman, B.S., Entomologist
Marco Montoya, Ph.D., Sociologist
Gerald K. O'Mara, Ph.D. candidate, Agricultural Economist
Robert R. Reynolds, Ph.D., Sociologist

This report was prepared under the general direction and supervision of Arnold L. Aspelin, Ph.D., Chief, Economic Analysis Branch, Criteria and Evaluation Division.

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Section I

INTRODUCTION AND SUMMARY OF FINDINGS

The purpose of this report is to provide an evaluation of economic and social implications of cancelling Chlordane/Heptachlor. In November, 1974, the Administrator of EPA announced his intent to cancel many of the major and minor Federally registered uses of pesticide products containing Chlordane and Heptachlor (hereafter referred to as C/H) (1). C/H are among the leading insecticides in the U.S. Significant economic and social benefits could be lost and dislocations caused in the switch to alternative pesticides, if and when the cancellation becomes effective.

The material presented in this report is intended to provide information and background for the environmental impact statement (EIS) issued on the proposed C/H cancellation, in keeping with the Administrator's policy of issuing voluntary EIS's (2). The results of recent economic research on pesticides and related important economic phenomena will be used in this analysis to draw implications from available data on the cancellation of C/H.

This report is devoted primarily to presentation of information on general production and distribution patterns of C/H (Section II) and to evaluation of impacts of cancelling agricultural uses (Section III - Corn and Section IV - Other Uses - largely agricultural). Section V relates to other areas of economic/social impact or concern such as energy implications and user adjustment problems.

The evaluation of the impacts of cancelling minor agricultural uses and nonagricultural uses is limited in scope. Limited data for these uses are available on the extent of use and on the comparative current performance characteristics which include cost, yield and efficacy data of C/H and alternatives.

The economic analyses to follow are conducted with the explicit assumption that aldrin and dieldrin will not substitute for chlordane and heptachlor.1/

1/ Adrin and dieldrin were suspended by the Administrator of EPA in August of 1974. Generally, a suspension order prohibits production of the pesticide in question but may allow use of existing stocks. A cancellation order is a less urgent action than suspension and allows continued production and use of the chemicals during the cancellation proceedings.

Background on the Nature of Benefits for Agricultural Uses of Pesticides

As an input in the agricultural production process, pesticides have played an important role in maintaining high yields per acre. Over time, pesticides, including C/H, have made land and labor more productive in important crop uses, thus freeing up resources for production of other crops. Measured in terms of productivity, pesticides are extremely important compared with other inputs.

Past attempts to measure the productivity of pesticides indicate a relatively high value on the average. Headley estimates marginal products of pesticide use in the United States to be about four (3). In England, Strictland estimated a 500 percent rate of return for pesticide use in that country (4). These rates of productivity and return are in sharp contrast with much lower returns for land and other agricultural inputs, which approach the competitive cost of capital in line with long term interest rates.

Pesticides, while being highly productive, are a small part of the total cost of producing a crop. For example, the cost of pesticides for growing corn is approximately one to three percent of the budget. Whether viewed in terms of absolute cost or cost relative to other productive inputs, pesticides are a modest, but important, investment.

A critical problem in pest management is that it is difficult to predict the likelihood of a pest infestation, its population size, and the resulting crop damage. In any given situation, the higher the risks, the greater is the farmer's incentive to use pesticides. Farmers tend to avoid risk and pesticides provide an economic means to reduce uncertainty of crop loss.

Related to this is the large variability in loss around the average crop loss. Carlson showed that for an investment in pesticides of $2 per acre, the variability in crop loss is reduced $11 per acre (5). A small investment in pesticide use has a large pay-off to the farmer in terms of reduced risk of crop loss. This risk-aversion phenomenon makes C/H appealing. They are persistent in the soil and are used as pre-emergence pesticides. They often are applied early in the season ahead of any infestation, rather than in response to an actual infestation as is commonplace with post-emergence applications. It is possible that much C/H is applied even though there may not be an actual infestation during the growing season. Although insecticides are applied on one-fourth of U.S. corn farms and one-third of the total farm acreage, the implication on a national level is that large amounts of C/H may have been applied which perform no useful insect control and the risks associated with release of C/H in the environment may not be fully compensated by production benefits (6, 7).

To some extent, optimal use of insecticides in C/H use patterns may be consistent with cancellation of C/H. There may be some overuse due to the combination of (a) high risk aversion on the part of some users, (b) less-than-optimum scouting of pest infestations, and (c) relatively low private cost compared with its social cost. Registered alternatives may be equally or more efficacious due to trends in pest resistance which are almost inevitable with extensive use of organic chemical insecticides over a period of years. Nonchemical alternatives, including use of resistant varieties and cultural practices such as crop rotations may be more fully exploited as environmental awareness increases through applicator training, education and regulation.

For some crops, the transition away from C/H can be made easily and inexpensively. In other cases, the transition may be more difficult due to more expensive and/or less productive substitutes. Although C/H are used in many situations, the emphasis in this report is on those C/H uses of greatest economic significance in agriculture.

Summary of Findings

I. Production and Use

A. Chlordane and heptachlor are products of Velsicol Chemical Corporation, a subsidiary of Northwest Industries. Production capacity for C/H currently is estimated to be in excess of 30 million pounds annually. Chlordane is used largely for nonagricultural purposes; the 1974 estimated use was as follows:

	Million Pounds
Agricultural	3.5
Termites	11.0
Home and garden and other	1.5
Total	16.0

B. Most agricultural use of chlordane is for crop protection, particularly protection of corn from soil insects. The primary industrial/commercial use is the protection of structures against termites. It is also used against a wide variety of home and garden pests.

C. Heptachlor, which is produced in much smaller volumes than chlordane, has been in the range of 2 to 4 million pounds per year during recent years. Estimated use in 1974 was as follows:

	Million Pounds
Agriculture	2.0
Termite control	1.4
Home and garden	0.6
Total	4.0

D. Agricultural use of heptachlor is almost entirely to protect crops, primarily corn.

II. Impacts of Cancelling C/H on Corn

A. C/H is used as a soil insecticide to protect corn primarily from rootworms, wireworms and cutworms although it is registered for use against other pests such as grubs, seed corn maggots and seed corn beetles.

B. The cutworm, principally the black cutworm, is the pest for which alternatives are most limited, thus generating the largest potential for benefits of continued C/H use.

C. Several alternatives are registered by EPA and recommended by the states for controlling each of the three principal pests: rootworms, wireworms and cutworms. For cutworms, limited pre-emergence alternatives are registered by EPA and recommended by the states. However, post-emergence rescue baits and sprays are registered and recommended in nearly all of the significant corn growing states.

D. The post-emergence rescue treatments for cutworms have the advantage of lowering costs since an application does not need to be made unless an infestation appears during the growing season. However, the rescue baits require that the farmer carefully scout his corn for pests.

E. In agricultural uses, more than half of the chlordane and nearly all of the heptachlor are used on corn (56 and 97%, respectively, for the year 1971).

F. C/H is used on only about 2.5% of U.S. corn acreage and 1.8% of corn farms (1.7 million acres and 17,300 farms in 1973). However, these numbers would be expected to increase considerably above 1973 levels as a result of the cancellation/suspension of aldrin because C/H substitutes for aldrin which has been used on about 10% of U.S. corn acreage.

G. Most corn farmers do not use insecticides of any type (75% in 1973) and most corn land is not treated (62% in 1973).

H. C/H use on corn is concentrated in Midwest states, principally Iowa, Missouri, Illinois, and Indiana which account for more than 70% of C/H use as of 1973.

I. C/H is much less expensive than other pre-emergence controls, roughly half the cost (e.g., $3.50 per acre compared with $7 per acre). Rescue treatments for control of cutworms generally cost less than recommended broadcast treatments (e.g., $2-$3 compared with $3-$4 per acre).

J. Use of alternatives to C/H will increase yields on rootworm infested land, but will have limited effects on wireworm infested land. These are the views of the preponderance of entomologists and other professionals who have reviewed this matter. However, some entomologists feel that there will be very limited or no yield effects, even on cutworm infested land, as alternatives are used. Estimates of yield reduction from use of alternatives on cutworm infested land vary from state-to-state within the range of 0 to 15% (and from 0 to 30% without the use of alternatives) under conditions of moderate to heavy cutworm infestations.

K. Earlier studies by the Department of Agriculture, Economic Research Service, indicated that cancellation of chlordane and heptachlor uses would have nominal impact on the corn sector of the economy. However, the results of these studies are no longer current or of sufficient analytical rigor to adequately reflect the actual impact generated by the combined cancellation of chlordane/heptachlor in addition to the suspension of aldrin/dieldrin. Therefore, EPA further evaluated the possible cancellation impact.

L. The EPA analysis involved the use of a linear programming (LP) model for agriculture showing impacts on acreage, production, prices, transportation costs, and monetary returns to agriculture for 127 regions of the United States, as affected by the combined cancellation of C/H and aldrin during the period 1975-80. Results of the LP analysis are presented in terms of the year 1977 which, for purposes of showing impacts on an annual basis, is assumed to be typical of the first five years of the effective cancellation. The LP analysis was based on moderate to heavy infestations.

M. Selected results of the LP analysis in terms of the year 1977 are as follows: corn production declines by 36.9 million bushels (0.7%); acreage of corn raised with no pesticides, up by +5.5 million acres; total corn acreage, +200,000 acres; total crop land, +1.16 million acres (0.4%); the price of corn and soybeans +1 to 3%; grain transport costs, +$6.36 million (0.9%); net returns to 7 major feedgrain crops, +$71.25 million (2.2%).

N. The worst case analysis of impacts which assumes moderate to heavy infestation levels of the cancellation on the corn sector translates into consumer price increases for meat products ranging between 0.4 and 0.5% and 0.10% for the entire consumer food basket.

III. Impact of Cancelling Other Agricultural Uses

A. Significant impacts are possible from the combined cancellation of aldrin/dieldrin and C/H for control of root feeding beetles on citrus in the state of Florida. Although C/H is not used extensively at this time for this purpose, and registrations at the Federal and state levels are inconsistent for this use, certain areas may become uneconomic if alternatives are incapable of controlling these pests. After a period of ten years as much as 5% of U.S. production could be affected if alternatives fail. Local economic and social impacts could be significant.

B. Significant economic and social impacts, as a result of cancellation of agricultural uses other than corn, seem unlikely in most cases. Effects on strawberry and potato production could be significant in local areas.

IV. Other Areas of Impact and Concern

A. Energy implications in terms of producing alternative chemicals are likely to be slightly positive as somewhat less energy will be required to produce alternatives on a pound-for-pound basis. On the other hand, energy implications of bringing 1.16 million more acres of land into production to meet needs have not been analyzed in detail. This increase in land devoted to the production of 7 major food and feed grains amounts to a 0.4% increase in land devoted to production of these crops.1/

B. Substantial land use impacts would occur in the North Central Region of the U.S., resulting in some reduction in the demand for farm labor in that region. For example, 9,400 workers could suffer individual income losses of $300 to $400 per year.

C. Velsicol Chemical Corporation, the producer of C/H, would suffer an income loss of up to $14 million according to Velsicol estimates.

D. The supply of substitutes for C/H is likely to be adequate by the time cancellation becomes effective and existing supplies are liquidated. It is expected that feedstock shortages and other problems of the energy crisis will have been resolved by the time the cancellation becomes effective. During a period of two years very large increases can be made in the production of alternative chemicals. There are opportunities to expand domestic supply in the short run by reducing exports or increasing imports of alternative chemicals. There are opportunities to expand domestic supply in the short run by reducing exports or increasing imports of alternative chemicals.

E. The use of alternative chemicals may require improved pest management and scouting by farmers. Training may be required in some cases.

F. Additional analysis of cancellation impacts of C/H use on corn is underway and will be completed during the cancellation proceeding. This further analysis will examine cancellation impacts in light of estimates of average infestation and yield performance of alternatives, rather than the extreme parameters which have been evaluated to date.

G. Substitutes are registered for most non-agricultural C/H uses, such as domestic, commercial and public health uses. Isolated instances of inadequate alternatives are possible.

1/ The seven crops are the endogenous crops in the linear programming model: corn, sorghum, wheat, barley, oats, soybeans, and cotton.

Conclusion

At the national level, cancellation impacts on production and prices of affected commodities are within the range of impacts due to normal year-to-year weather and market variations, making the impact significant but not serious. Local areas and regions could be affected more seriously, as in the case of moderate to heavy infestations of corn soil pests and poor performance of alternative controls. Such outcomes are unlikely to occur in all areas of the U.S. in one year, but they are possible.

Throughout the analyses of impacts of the proposed C/H cancellation, limited weight has been given to trends in the development of substitutes and the decline in use of C/H due to pest resistance, which usually develops with intensive long term use of a pesticide. These factors would be expected to reduce the benefits of continued use of C/H, over a period of years compared to substitutes as indicated by current data on yield and cost. During a 5 or 10 year period, benefits of continued C/H use could decline to negligible levels.

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(6) Aspelin, Arnold L., *Statement for Testimony at Aldrin/Dieldrin Suspension Hearing* (Exhibit 5-16), Washington, D.C., September 1974, Appendix A, Table 1.

(7) Midwest Research Institute Report. *A Study of the Efficiency of the Use of Pesticides in Agriculture*, prepared for EPA, February 1975.

Section II

PRODUCTION AND DISTRIBUTION OF CHLORDANE/HEPTACHLOR

Presented in this section are data on the supply of C/H, including production and export/import figures, and general use patterns by geographic area. Available data on production and use are quite sketchy.

Certain production/use data available to EPA are not reported herein because of confidentiality of sources (e.g., annual reports to EPA on registered pesticide establishments under Section 7, Federal Insecticide, Fungicide, and Rodenticide Act, as amended, 1972, and confidential industry estimates). Principal emphasis is on production of technical C/H and general use patterns. Data are not presented on formulation, marketing and application of C/H.

Production

C/H are products of Velsicol Chemical Corporation, a subsidiary of Northwest Industries. The Chemical Group of Northwest Industries, Inc. which includes Velsicol Chemical Corporation and Michigan Chemical Corporation had net sales of $167 million in 1974. About two-thirds of Velsicol's annual sales are concentrated in pesticide products (1). Total production capacity for C/H at this time is probably in excess of 30 million pounds annually as capacity for chlordane production alone was estimated at 30 million pounds in 1972 (2, p. 152). In that year production of chlordane was estimated at 20 million pounds, of which 5 million was exported (2, p. 152). Production capacity for heptachlor is estimated to be in the range of 3 million pounds annually for domestic use, (3) plus some capacity for export. Apparently, C/H is not imported into the U.S.

Chlordane Use Patterns

Chlordane has been used as a registered commercial insecticide for more than 25 years. It is the second oldest organochlorine insecticide, preceeded only by DDT. Although chlordane is an important agricultural pesticide, most of its use is non-agricultural. According to the most recently published estimates (1972), only 3 million pounds were used in agriculture compared with 6.5 million for industrial/commercial uses, primarily termite control; 0.5 million for Government agencies; and 5.0 million for homes and gardens, out of total domestic use of 15 million pounds (2, p. 153). A breakdown, by region, of these U.S. totals is presented in Table 1. Most chlordane is used in the central and eastern regions of the U.S.

For the year 1974, total domestic use was 16 million pounds, according to EPA estimates based on informal industry sources. This total breaks down as follows: agriculture - 3.5 million, termites - 11 million and home/garden and others - 1.5 million.1/ It is not clear at this time exactly what the proportional breakdown is among non-agricultural uses in view of the differences between the 1972 and 1974 estimates.

Agricultural Uses

According to USDA surveys, crop uses account for 70% to 85% of agricultural use of chlordane in the U.S. (Table 2). Some is used around livestock buildings and less than 5% is used for other purposes on farms. There is no trend shown in the USDA surveys as to changes in percentage breakdown among general types of agricultural uses. However, there appears to be a trend toward increased use of chlordane in agriculture generally, inasmuch as the 1971 use level of nearly 1.9 million pounds was more than three times that for 1964 and 1966 (Table 2), and a more recent EPA estimate indicates about 3.5 million pounds for 1974. The suspension of aldrin/dieldrin will increase demand for chlordane, along with other substitutes, leading to increased production and use of chlordane beginning 1975 or 1976.

The major uses of chlordane on crops are shown in Table 3. Corn is the leading use, with 842,000 pounds active ingredient on 533,000 acres in 1971, followed by apples, nursery and greenhouse uses which together account for most of the remainder, according to USDA.2/

1/ More recent use data was provided by Velsicol Chemical Corporation in June 1975, subsequent to the completion of this study. The data indicate that a total of 21,177,065 pounds of technical chlordane was used in 1974. The breakdown of this use is as follows: agricultural - 6,007,358 pounds; termite control - approximately 6,608,030 pounds; all other - approximately 8,561,677 pounds.

2/ The estimate for chlordane use on apples is believed to be in error, as use of chlordane on apples is uncommon.

Between 1966 and 1971, large increases occurred in corn, other grains, and nursery greenhouse uses, while alfalfa and Irish potato use declined notably. Corn, other grain and Irish potatoes accounted for most of the 717,000 crop acres treated with chlordane in 1971 (Table 3).

Table 1 .. Domestic use of chlordane by geographic region of U.S., 1972

Region	Agricul-tural	Industrial, Commercial	Government Agencies[a]	Sub-Totals	Home and Garden[b]	Total
NE	0.7	1.0		1.7		
SE	0.3	1.3		1.8		
NC	1.7	1.6		3.4		
SC	0.1	1.3		1.6		
NW	0.1	0.3		0.4		
SW	0.1	1.0		1.1		
Total	3.0	6.5	0.5	10.0	5.0	15.0

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[a] Too small to break out; included in subtotals.

[b] Geographic distribution not known.

SOURCE: Midwest Research Institute and RvR Consultants; Production, Distribution, Use and Environmental Impact Potential of Selected Pesticides, for EPA/CEQ, 1974.

Table 2-- Agricultural use of chlordane by type of use, U.S., 1964, 1966 and 1971 (active ingredient basis)

Year	Type of Agricultural Use			
	Crops	Livestock[a]	Other[b]	Total
	1,000 pounds a.i.			
1964	383	142	20	545
1966	452	71	3	526
1971	1,496	366	28	1,890
	Percent of Total			
1964	70.3	26.0	3.7	100
1966	85.9	13.5	0.6	100
1971	79.1	19.4	1.5	100

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[a] Includes livestock buildings

[b] Includes all other nonlivestock and noncrop uses.

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 131, 179 and 252).

See references (4), (5) and (6).

Table 3-- Chlordane use on crops, U.S., 1966, 1971

Crop	Quantities 1966	Quantities 1971	Acres Treated 1966	Acres Treated 1971
	1,000 pounds active		---1,000 acres---	
Corn	159	842	210	533
Other grains	-	41	-	78
Cotton	3	-	6	-
Tobacco	26	2	17	1
Potatoes	155	33	38	55
Crops	1	29	2	16
Alfalfa	41	-	36	-
Other hay and pasture	6	2	23	3
Irish potatoes	155	33	38	55
Other vegetables [1/]	18	16	23	7
Citrus	15	18	83	10
Apples	3	373	3	10
Other fruits and nuts	24	7	31	4
Nursery and green-house	1	133	NA	NA
TOTAL	452	1,496	472	717

Note: In 1964, USDA included chlordane in the category of "Other organochlorine insecticides."

[1/] Includes strawberries.

Source: USDA/ERS (Agricultural Economic Report Nos. 179 and 252). See references (5) and (6).

The USDA estimate of 533,000 acres of corn treated with chlordane in 1971 is considerably less than the 1973 acreage according to data presented at the aldrin/dieldrin suspension hearings.(3) This data indicated chlordane was used on 812,000 acres or 1.2% of U.S. corn acreage in 1973.

Heptachlor Use Patterns

General Use Patterns

Although heptachlor was introduced and registered more than 20 years ago, it is much less widely used than chlordane. Very limited data are available on all uses, especially nonagricultural uses. Total production during recent years has been in the range of 2-4 million pounds, some of which is exported. An approximate breakdown of 1974 use is as follows: [1/]

	Million Pounds	Percent
Agriculture	2.0	50
Home & Garden	.6	16
Termite Control	1.4	34
Total	4.0	100

In the past, about half of heptachlor was used in agriculture but this may be changing due to the aldrin/dieldrin suspension. As much as 3 million pounds may be used for agriculture in 1975 (3).

Agricultural Uses

USDA's Economic Research Service surveys indicate agricultural heptachlor use in the range of 1.2 to 1.5 million pounds annually during the last 10 years, mostly to protect crops (Table 4). Livestock uses are insignificant and other uses accounted for only 5.6% in 1971. Heptachlor is used mainly on corn, as other uses have declined to no more than a few thousand acres, according to USDA's 1971 survey (Table 5).

[1/] The 1974 use data for heptachlor in pounds of technical equivalent material provided in June 1975, by Velsicol Chemical Corporation subsequent to the completion of this study is as follows: agricultural - 1,456,190 pounds; termite control - approximately 496,502 pounds; all other - approximately 99,579 pounds.

Table 4-- Agricultural use of heptachlor by type of use, U.S., 1964, 1966 and 1971 (active ingredient basis)

Year	Type of Agricultural Use			
	Crops	Livestock[a]	Other[b]	Total
	1,000 pounds a.i.			
1964	1,301	-	4	1,305
1966	1,513	3	20	1,536
1971	1,143	-	68	1,211
	Percent of Total			
1964	99.7	-	0.3	100
1966	98.5	0.2	1.3	100
1971	94.4	-	5.6	100

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[a] Includes livestock building

[b] Includes all other non-livestock and non-crop uses

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 131, 179 and 252).

See references (4), (5), and (6).

Table 5 --Heptachlor Use on Crops, U.S., 1964, 1966, 1971

Crop	Quantities			Acres Treated		
	1964	1966	1971	1964	1966	1971
	----1,000 pounds active----			------1,000 acres------		
Corn	1,099	1,484	1,104	1,427	2,026	1,901
Cotton	a/	-	-	a/	-	-
Tobacco	24	7	-	17	3	-
Alfalfa	-	3	3	-	12	14
Other hay and pasture	-	18	1	-	48	2
Other field crops	169	b/	-	279	4	-
Other vegetables	a/	1	34	a/	6	10
Apples	-	-	1	-	-	c/
Citrus	-	b/	-	-	-	-
All other fruits and nuts	-	b/	-	-	2	-
TOTAL	1,301	1,513	1,143	1,727	2,103	1,927

a/ Less than 10,000 acres treated.

b/ Less than 500 pounds.

c/ Less than 500 acres.

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 179 and 252).

See references (5) and (6).

References for Section II

(1) "Kline Guide to the Chemical Industry," 1974, p. 273.

(2) Midwest Research Institute and RvR Consultants. Production, Distribution, Use and Environmental Impact Potential of Selected Pesticides. For EPA and CEQ. Midwest Research Institute, Kansas City, Mo., 1974.

(3) Transcript, Aldrin/Dieldrin Suspension Hearings, Exhibit S-16, Statement 64 Arnold Aspelin, OPP, EPA, September 1974.

(4) USDA, Quantities of Pesticides Used by Farmers in 1964, AER No. 131, ERS, USDA, Washington, D.C., January 1968.

(5) USDA, Quantities of Pesticides Used by Farmers in 1966. AER No. 179. ERS, USDA, Washington, D.C. April, 1970.

(6) USDA, Farmers' Use of Pesticides in 1971-Quantities, AER No. 252. ERS, USDA. Washington, D.C. July, 1974.

Section III

ECONOMIC IMPACTS OF CANCELLING CHLORDANE/HEPTACHLOR USE ON CORN

Introduction

Corn is the most important crop in the U.S. More acres of cropland are planted to corn, and more farm income is generated from it than from any other crop. Corn is grown on about 70 million acres, on 1 million farms, resulting in production of 5 to 6 billion bushels of grain annually. Soybeans and wheat are grown on nearly as many acres (45 to 50 million, compared with 60 to 70 million for corn) but are much less important in terms of income to agriculture (1). At $3 per bushel, the corn crop is valued at $15 billion or more, far in excess of other crops such as soybeans ($7 or $8 billion); cotton ($3 or $4 billion) and tobacco ($2 or $3 billion). Corn accounts for about 75-80% of all grains fed to livestock and poultry in the U.S. and is important as both food and feed in much of the world (2).

In this section we will evaluate the impacts of shifting to alternative insecticides for control of corn pests. Attention is paid to cost, yield, acreage, production and price effects of the cancellation. Earlier studies are reviewed and preliminary worst case estimates are reported by region for the U.S. based on results of a linear programming analysis of U.S. agriculture for the period 1975-80, typical year basis.

Principal Target Pests

Corn is subject to attack by a wide variety of insects including corn rootworms, wireworms, cutworms, grubs, seed corn maggots, and seed corn beetles. Testimony in the aldrin/dieldrin cancellation hearings established that the primary soil insects presenting economic threats to U.S. corn production are rootworms, cutworms, and wireworms (3). This analysis concentrates on these three insects. Chlordane and/or heptachlor have EPA registrations for use against a number of other corn pests, which are of minor economic significance in terms of actual damage and use of C/H (Appendix A, Table 1).

Rootworms are by far the principal corn insect pests for which soil insecticides are used. About 200,000 farms (14% of U.S. corn farms) are estimated to consider rootworms a major problem on their farms; 70% of these are treated. In 1973, an estimated 15 million acres (21.9% of U.S. acreage) were treated for rootworms, while an additional 6 or 7 million acres on farms with problems were not treated (Table 6).

Approximately 51,000 farms were estimated to consider cutworms a major problem in 1973; about 58% were treated for them. This is estimated at 3.2 million acres, or about 4.6% of U.S. corn acreage (Table 6). This percentage was near the estimate for wireworms (4%) but far below the figures for rootworms (21.9%).

Wireworm problems were estimated to have occurred on about 35,000 farms in 1973 (Table 6) leading to treatment of 2.8 million acres. More than 70% of farms with wireworm problems used an insecticide, based on the available 1973 data.

Infestations of cutworms and wireworms are much more sporadic than rootworms and the acreage treated varies greatly from year to year. The number of corn farms with cutworm problems can range to as many as 75,000 (compared with 50,000 in 1973). Similarly, the number of farms with wireworm problems may vary from 30,000 to 50,000.

State-by-state breakdowns, by target pest, on the number of farms and estimated acreage treated in five principal corn states are shown in Table 6. Missouri had the highest percentage of acreage treated for cutworms (15.5%, more than twice Illinois, which ranked number 2 in 1973). Missouri and Illinois also ranked above the other states in percent of acreage treated for wireworms (10.1 and 9.2%, respectively) (Table 6). Iowa and Illinois are by far the leading states in acreage treated for rootworms (21.6 and 32.1%, respectively, in 1973)(Table 6).

The data in Table 6 indicate that 25 to 40% of U.S. corn farms impacted by one of these three major corn pests do not treat for the pest. This suggests that significant numbers of corn farms troubled by these pests do not project economic threshold levels of damage. However, some of these farms not treating may, in fact, sustain economic infestation during the year. Next, we will consider alternative means of controlling these pests.

Table 6

Farms reporting problems with selected corn pests, number of farms treating and amounts of pesticide required, major corn states and U.S., 1973

	Unit	Ohio	Ind.	Ill.	Iowa	Mo.	Total (5 states)	Other States	U.S.
Rootworms									
No. of farms rptg. problems	No.	6,012	9,405	21,750	50,964	7,298	95,429	104,403	199,832
Farms treating									
No.	No.	4,341	5,092	16,390	41,626	4,717	72,166	56,169	138,336
Pct. of those rptg. problems	Pct.	72.2	54.1	75.4	81.[illegible]	64.6	75.6	62.4	69.2
Pct. of total corn farms	Pct.	7.9	8.8	18.3	35.4	10.3	19.7	11.0	14.3
Treated acreage (approx.)1/	Acres (000)	411	782	2,182	3,825	371	7,571	7,847	15,418
Treated acreage as pct. of total corn	Pct.	11.5	14.1	21.6	32.1	13.0	22.3	21.5	21.9
Cutworms									
No. of farms rptg. problems	No.	3,990	3,024	9,230	9,573	7,547	33,364	17,460	50,824
Farms treating									
No.	No.	1,713	2,180	5,851	6,116	5,342	21,202	8,060	29,262
Pct. of those rptg. problems	Pct.	42.9	72.1	63.4	63.9	79.8	63.5	46.2	37.6
Pct. of total corn farms	Pct.	3.1	3.8	6.5	5.2	11.7	5.8	1.3	3.0
Treated acreage (approx.)1/	Acres(000)	163	336	778	563	422	2,262	90[illegible]	3,248
Treated acreage as pct. of total corn	Pct.	6.3	6.4	7.7	4.7	15.5	6.7	2.7	4.6
Wireworms									
No. of farms rptg. problems	No.	2,228	2,281	8,268	6,423	4,194	23,394	11,576	34,970
Farms treating									
No.	No.	2,052	1,961	6,984	4,780	3,636	19,413	5,741	25,154
Pct. of those rptg. problems	Pct.	92.1	86.0	84.5	74.4	86.7	83.0	49.6	71.9
Pct. of total corn farms	Pct.	3.3	3.4	7.8	4.1	7.0	5.0	1.0	2.6
Treated acreage (approx.)1/	Acres(000)	195	302	929	440	287	2,153	639	2,792
Treated acreage as pct. of total corn	Pct.	7.6	5.4	9.2	3.7	10.1	6.3	1.8	4.0

1/ Average acreage of land treated per farm in state (all chemicals) x no. of farms treating for specific pest.

SOURCE: Aldrin/dieldrin Suspension Hearings, Exhibit S-16(5).

Alternative Controls

The purpose of this section is to briefly summarize relevant information on registration and recommendations of C/H and their alternatives for control of corn soil insect pests. Focus is on controls registered with EPA and those recommended by the states.

Chlordane and heptachlor are registered with EPA for control of rootworms, cutworms and wireworms as are a number of alternative controls (Table 7).

Table 7 -- EPA registered nonfoliar controls for rootworms, cutworms, and wireworms in corn, 1974.

Pesticide Chemical	Rootworms	Cutworms	Wireworms
Chlordane	x	x	x
Heptachlor	x	x	x
Bux	x	-	-
Carbaryl	-	x	-
Carbofuran	x	-	x
Counter	x	-	x
Dasanit	x	-	x
Diazinon	-	x	x
Di-Syston	x	-	-
Dyfonate	x	-	x
Mocap	x	-	x
Parathion	x	x	x
Phorate	x	-	x
Toxaphene	-	x	-

SOURCE: Preliminary summary of registered chlordane and heptachlor uses and alternatives, Criteria and Evaluation Division, OPP, EPA.

NOTE: Aldrin use against these pests has been suspended by EPA except for existing leftover stocks.

Alternatives to C/H and other organochlorine insecticides are becoming increasingly attractive because of insect resistance to this class of insecticides, superior performance of alternatives and problems with organochlorine contamination of agricultural food crops. 1/ Use of organochlorines is often not recommended under a number of situations such as: dairy farms; farms on which any live stock are raised; crop rotations in which soybeans (a major crop in corn areas) follow corn; continuous corn cropping; rotations in which root crops follow corn; and corn used for silage or fodder. Also, states are limiting recommendations to specific situations and geographic areas where pest problems are most likely to occur, such as certain types of land and rotations, where land is known to have a history of soil insect problems and where resistance has not yet developed.

Rootworms

Rootworms are best controlled by crop rotations to avoid corn-after-corn, and by pre-emergence row treatment with nonorganochlorine soil insecticides. Most rootworms have become resistant to C/H and other organochlorines during the last 15 years with the result that they are no longer preferred and only rarely recommended for controlling rootworms in corn. C/H and aldrin are not recommended by state entomologists for use against rootworms in most major corn growing states according to 1974 state insecticide recommendations (Table 8). The only major corn state recommending use of an organochlorine against rootworms was Indiana where aldrin and heptachlor were recommended in the Northern 1/3 of the state. For each of the major corn producing states, there are usually five or more EPA registered pesticides recommended by state entomologists as alternatives to C/H for control of corn rootworms. These controls are commonly applied at planting time in a 7 inch subsurface band over the row, with an insecticide attachment to the planter. This method of treatment is in contrast to furrow and with broadcast treatment which involves treating the entire crop area, including space between the rows. With broadcast treatment, the pesticide is applied with a spreader and incorporated into the soil with a disk or harrow. Boradcast treatment is recommended for control of wireworms and cutworms as discussed below.

1/ Use of feed contaminated with organochlorine residues resulted in more than 4 million broilers being contaminated with illegal residues in 1974, making it necessary to destroy them.

Table 8. Controls recommended for rootworms in corn, major corn growing states, 1974.

State	Bux	Carbofuran	Dasanit	Dyfonate	Landrin	Mocap	Phorate	Diazinon
Illinois	B	B	B	B	B	B	B	-
Indiana [1]	B	B	B	B	-	B	B	-
Iowa	B	B	B	B	B	B	B	-
Kansas	B	B	B	B	-	B	B	-
Michigan	B, Br	B	B	B	-	B	B	-
Minnesota	B	B	B	B	-	B	B	B
Missouri	B	B,F	B	B	-	-	B	-
Nebraska	-	B	B	B	-	-	B	-
Ohio	B	B	B	B	-	B	B	-
South Dakota	-	B	B	B	-	B	B	-

[1] Aldrin and C/M were recommended for northern 1/3 of Indiana in 1974.

Legend:

B - Band treatment

BR - Broadcast treatment

F - Furrow treatment

Source: State insecticide recommendations, 1974.

Wireworms

Wireworm damage to corn seeds, emerging seedlings and roots can be minimized by pre-emergence treatment in the furrow with the seed at planting time, by band treatment and by broadcast treatment using any of several pesticides which are registered by EPA and recommended by the states. A two-year corn-soybean rotation is also helpful.

Historically, organochlorine pesticides have been the preferred control for wireworms in corn. However, increasing resistance or suspected resistance to organochlorines of some wireworm species and the availability of alternatives are combining to reduce the importance of C/H and aldrin in control of wireworms. Presently, EPA-registered alternatives to C/H include carbofuran, counter, mocap, dasanit, diazinon, dyfonate, phorate and parathion (Table 7). At least two of these alternatives to C/H and aldrin are recommended by entomologists in most major corn states, excluding Nebraska and Ohio, with four or five in some states (Table 9). Toxaphene is not recommended in any leading corn states.

Aldrin and heptachlor were recommended in most corn states for control of wireworms in 1974. However, chlordane was recommended for control of wireworms in only three major corn states (Table 9). In 1975, Indiana will add to its recommendations dasanit and mocap as row treatments against wireworms and Iowa will add diazinon and dyfonate (4).

Cutworms

The primary cutworm problem in the midwestern corn producing states is the black cutworm which cuts the corn stalk just above the ground during the wet weather and initiates subsurface feeding during dry weather. Problems with this insect are associated with flooding conditions following stream overflows or standing water. The areas most heavily impacted are black, heavy, river bottom soils of alluvial origin.

The most widely recommended control for cutworms has been broadcast pre-emergence treatment with aldrin, although heptachlor was also recommended; it substitutes essentially on a one-to-one basis for aldrin. As of 1974, pre-emergence broadcasting of heptachlor was recommended for use in most corn states (Table 10). Chlordane is not generally recommended for cutworm control (only Iowa, Minnesota and Nebraska recommended it in 1974). Band application of aldrin and C/H are not generally recommended, with Iowa as the only exception. Furrow treatment is not recommended in any major corn state for cutworms.

The entomology profession is divided at the moment on whether alternatives to C/H and aldrin pre-emergence treatment are effective against cutworms attacking corn. Diazinon was the only recommended nonorganochlorine pre-emergence treatment for cutworms in 1974. Entomologists, with seemingly similar conditions, cannot agree on whether farmers can adequately protect their crops with alternatives, primarily the postemergent sprays and baits. For example, in Missouri entomologists recommend pre-emergence treatment with heptachlor and aldrin, whereas in adjoining Illinois, only post-emergence rescue treatment with baits and sprays is recommended (Table 10).

Table 9. Controls recommended for wireworms in corn, major corn growing states, 1974.

				Non-organochlorine alternatives						
State	Chlordane	Heptachlor	Aldrin	Carbofuran	Dansanit	Diazinon	Dyfonate	Mocap	Phorate	Parathion
Illinois	-	-	-	B	B	B	B	B	B	-
Indiana	-	Br	Br	F	-	Br	Br	-	B	-
Iowa	-	F	F	B	-	-	-	-	B	-
Kansas	-	Br	Br	B	B	B,Br	B	B	B	-
Michigan	B,Br	-	-	-	-	B,Br	-	-	-	Br
Minnesota	Br	Br	Br	-	B	-	B	-	B	-
Missouri	-	Br	Br	-	B	-	B	-	B	-
Nebraska	Br,F	Br,F	Br,F	-	-	-	-	-	-	-
Ohio	-	Br	Br	-	-	-	-	-	-	-
South Dakota	-	Br	Br	-	-	Br	Br	-	-	-

Legend: B - Band treatment
Br - Broadcast treatment
F - Furrow treatment

Source: State insecticide recommendations, 1974.

Table 10. Controls recommended for cutworms in corn, by type, major corn growing states, 1974

State	Pre-emergence				Rescue					
					Carbaryl		Toxaphene		Trichlorfon	
	Aldrin	Heptachlor	Chlordane	Diazinon	Bait	Spray	Bait	Spray	Bait	Spray
Illinois	-	-	-	-	x	x	-	-	x	x
Indiana	Br	Br	-	Br	x	x	-	x	x	x
Iowa	B	B	B	-	x	-	-	-	-	-
Kansas	Br	Br	-	-	x	x	-	x	x	-
Michigan					-	x	-	-	-	x
Minnesota	Br	Br	Br	B	x	x	-	x	-	x
Missouri	Br	Br	-	Br	x	x	-	x	-	x
Nebraska	Br	Br	Br	-	x	x	-	-	-	x
Ohio	Br	Br	-	-	-	x	-	x	-	x
South Dakota	Br	Br	-	B	x	x	-	x	-	x

Legend: Br - Broadcast treatment
B - Band treatment

Source: State insecticide recommendations, 1974.

Each state recommends cutworm rescue treatments such as sprays and baits as alternatives to pre-emergence treatments (Table 10). These post-emergent treatments, when properly applied to an infestation reaching an economic level, are effective in controlling cutworms. Weather conditions can alter insect control as bait formulations are adversely affected by rain and very dry conditions cause cutworms to feed at subsurface levels. These controls have the advantage of avoiding costs, since they are used only when needed, and are less likely to breed resistance in pest populations. These post-emergent treatments include the currently EPA-registered carbaryl and dylox baits and sprays and toxaphene spray. The most often recommended of these treatments is the carbaryl bait.

The post emergent baits and sprays require careful scouting by the farmer during the period when corn is subject to cutworm damage. There is a need for more training on the proper application and timing of controls in line with economic thresholds.

With aldrin and C/H cancelled, corn producers would have very limited pre-emergence treatments for cutworms. However, some recent tests are encouraging in this regard. Experiments in Illinois in 1974 to test carbofuran as a systemic control of the black cutworm indicates that band and especially furrow treatments will control the pest. Luckmann from Illinois indicates that they will probably suggest this alternative to farmers in 1975 (6).1/ Peters testified that his tests for cutworm control indicated that carbofuran was promising (7).

Existing data reveal that chlorinated hydrocarbons do not always provide adequate cutworm control. Of the 15 fields investigated in an EPA study, six had been treated with chlorinated hydrocarbons and damage to these fields ranged from 6% on the only aldrin treated field to 85% on a heptachlor treated field (32). Damage to the chlorinated hydrocarbon treated field averaged 35% stand reductions in the heavily infested portions of the fields.

Peters indicated that alternatives exist to chlorinated hydrocarbons for control of soil insects. He said: "The trends in the data lead me to feel quite strongly that in a given situation, there are one or more organophosphate or carbamate insecticides that will control soil insects as well as aldrin or heptachlor at the same rate per acre." (8, p. 2) He indicated that costs would be higher with the alternatives and the only areas that should be treated are those where cutworms are a known problem.

Peters also noted that a major problem in the control of cutworms seems to be the tendency for farmers to place chlorinated hydrocarbons in the furrow, or band a 1 lb a.i. per acre rather than broadcast at a higher rate (1.5 to 2 lbs) as is generally recommended for cutworms. (8, p. 4) This point was also made during conversations of EPA and University of Missouri personnel with a large scale John Deere farm implement supplier in Carrollton, Missouri in May, 1974 (9). This dealer indicated that four-fifths of the

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1/ However, follow-up tests in 1975 in Illinois indicate that carbofuran systemically is not a reliable control for cutworm (Luckmann, personal communication, 1975).

farmers purchasing equipment from him purchased insecticide planters adapted for row applications of insecticides and that such applications were the common practice in this area where heavy soils and cutworm infested bottomland predominate. This is consistent with cost data available to EPA which indicate that most aldrin and heptachlor is applied in the row rather than boradcast applications as is needed to control cutworms according to state recommendations.[1] Indications are that many cutworms are targeted with row (furrow or band) treatment, which is not recommended by either EPA or state recommendations.

In conclusion, corn farmers have available to them a very limited selection of recommended pre-emergence treatments, as alternatives to C/H and aldrin, to control cutworms in corn (only diazinon in 1974). It is thought that aldrin or heptachlor provide more effective control of cutworms than diazinon.

The rescue treatments are not widely used, and require scouting to determine the need and timing for treatment. Such scouting represents a new concept for many farmers, some of whom may need additional training and information to properly use such treatments to maximum benefit. One survey of midwest corn states produced the following generalization: "Experts in the field generally concur that up to 50% of theoretically infested corn acreage is treated needlessly." (11, p. 8)[2]

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[1] An evaluation of 1973/74 expenditure data for chlordane in the U.S. indicates that average insecticide cost per acre treated was $1.91. At the recommended broadcast rate of 2 pounds active ingredient per acre this implies a price per pound of $0.95, which was far below the going price in 1974 (about $2.00/pound).

[2] This has been confirmed by a more recent study which indicates that 50 percent of insecticides used on corn are used needlessly (Midwest Research Institute, July 1975).

Use Patterns for C/H and Other Controls

National Level

In 1971, 56% of the chlordane and 97% of the heptachlor were used on corn (Table 3 and Table 5). Although these figures are substantial, C/H are not used on very large percentages of U.S. corn acreage or corn farms. As of 1973, C/H was used on only 2.5% of U.S. corn acreage and 1.8% of farms (1.7 million acres and 17,300 farms out of 70.5 million acres and nearly 1 million farms) (Table 11). Actually most corn farmers (75% in 1973) do not use corn insecticides of any type and a majority of corn land (61.8% in 1973) is not so treated (Table 11).

Use of C/H to protect corn can be expected to increase as a result of the aldrin suspension. Aldrin was used on 10.6% of U.S. corn acreage in 1973 (10% in 1974). It is also expected that heptachlor use would have increased notably, to as much as 3 million pounds in 1975 (10). Heptachlor substitutes somewhat more readily for aldrin on an economic basis than does chlordane.

Regional and State Levels

Data on the extent of heptachlor and chlordane use on corn arc available from several sources. The farm pesticide use surveys of the Economic Research Service (ERS) of USDA estimated use of heptachlor and chlordane on corn, by region, for the years 1966 and 1971. The data, presented in Table 12, shows no clear trend for total national use of heptachlor, while use of chlordane more than doubled from 1966 to 1971. Nearly all of the heptachlor is used in the Corn Belt and chlordane is used largely in the Corn Belt plus the Lake States, according to these surveys.

According to data presented at the aldrin/dieldrin suspension hearings, heptachlor and chlordane use on corn is concentrated in five Corn Belt states: Iowa, Missouri, Illinois, Indiana and Ohio. These five states accounted for more than 70% of C/H treated corn acreage in 1973 (1,237,000 acres) while these states had only 48% of U.S. corn

Table 11 -- Acreage and number of farms applying insecticides on corn, U.S. 1973

Treatment	Acreage		Farms	
	No. (1000)	Percent	No.	Percent
Aldrin	7,448	10.6	70,378	7.3
Belt (Chlordane)	812	1.2	8,328	0.9
Heptachlor	901	1.3	9,054	0.9
Sevin	360	0.5	8,839	0.9
Other Carbamates	8,753	12.4	92,352	9.5
Phosphates	7,794	11.5	79,251	8.2
Other Phosphates	860	1.2	13,638	1.4
Total treated	26,928	38.2	241,607[a]	24.9[a]
Not treated	43,561	61.8	728,416	75.1
Total	70,489	100.0	970,023	100

[a] Items do not add to totals because many farms applied more than one of the pesticides.

SOURCE: Aldrin/dieldrin suspension hearings - Exhibit S-16.

Table 12 -- Regional Corn acreage treated with chlordane and heptachlor, 1966, 1971

Region	Heptachlor 1966	Heptachlor 1971	Chlordane 1966	Chlordane 1971
Northeast	15	62.1	3	4.8
Lake States	150	31.4	85	159.0
Corn Belt	1,718	1,807.3	102	342.9
Northern Plains	131	-	-	-
Appalachia	*	-	-	22.8
Southeast	-	-	20	3.7
Delta	11	-	-	-
Other Regions	1	-	-	-
Total U.S.	2,026	1,901	210	533.2

*Less than 500 acres

SOURCE: Jenkins, et. al., "Economic Impact of Discontinuing Farm Uses of Chlordane," USDA-ERS, 1972

Delvo, et. al., "Economic Impact of Discontinuing Farm Uses of Heptachlor", USDA-ERS, 1972

Andrilenas, Paul, "Farmers' Use of Pesticides, 1971", USDA-ERS, 1974 acreage that year (70.5 million acres) (Table 13).[1]

Chlordane is used mainly in Ohio, Indiana and Illinois, on about 2 to 3% of the corn grown in those states (Table 13).

Heptachlor use is centered in Illinois and Iowa, where its use equalled 5.8 and 1.8% of total corn acreage in 1973. Chlordane use is less heavily concentrated in remaining states as more than 350,000 acres were treated in states other than the 5 Corn Belt states identified in Table 13.

The number of farms using C/H, as reported in Table 14 for 1973, are in line with numbers of acres treated. Illinois has the heaviest concentration of C/H users with 5,400 (6% of corn farms). Iowa was next with about 3,700 users (heptachlor only).

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[1] Estimates of the extent of heptachlor and chlordane use on corn are available from several other sources. Under an EPA contract, Theodore Riedeburg Associates (11) derived estimates of soil insecticide use in four major corn producing states. Their estimates are higher than those from other sources. Delvo presented limited data on heptachlor use in his analysis (12) of the impact of cancelling farm uses of aldrin. Also, the five Lake States of Indiana, Illinois, Michigan, Minnesota and Wisconsin published use data. These reports give limited data on corn acreages treated in the Great Lakes region (13 and 14). Estimates for 1974 have been provided by extension entomologists and are included in Appendix B.

Table 13--Acreage of Corn Treated with Insecticides, Major Corn States, and U.S., 1973

Treatment	Ohio	Indiana	Illinois	Iowa	Missouri	Total (5 states)	Other States	U.S.
				Acreage (000)				
Aldrin	758	1,217	1,722	1,733	783	6,213	1,235	7,448
Chlordane (Belt)	113	142	191	---	---	446	366	812
Heptachlor	---	---	581	210	---	791	110	901
Sevin	---	---	---	---	---	---	360	360
Other Carbamates	91	77	913	1,778	209	3,068	5,685	8,753
Phosphates	---	64	1,555	1,779	---	3,398	4,396	7,794
Other	104	74	159	249	104	690	170	860
Total Treated	1,066	1,574	5,121	5,749	1,096	14,606	12,322	26,928
Not Treated	2,504	3,986	4,979	6,151	1,754	19,374	24,187	43,561
TOTAL	3,570	5,560	10,100	11,900	2,850	33,980	36,509	70,489
				Percent of Total Acreage				
Aldrin	21.3	21.9	17.0	14.6	27.5	18.3	3.4	10.6
Chlordane (Belt)	3.2	2.5	1.9	-	-	1.3	1.0	1.2
Heptachlor	-	-	5.8	1.8	-	2.3	0.3	1.3
Sevin	-	-	-	-	-	-	1.0	0.5
Other Carbamates	2.5	1.4	9.0	14.9	7.3	9.0	15.6	12.4
Phosphates	-	1.2	15.4	14.9	-	10.0	12.0	11.0
Other	2.9	1.3	1.6	2.1	3.6	2.0	0.5	1.2
Total Treated	29.9	28.3	50.7	48.3	38.6	42.9	33.8	38.2
Not Treated	70.1	71.7	49.3	51.7	61.4	57.1	66.2	61.8
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE: Other carbamates principally include carbofuran and bux ten; phosphates principally include dasanit, dyfonate, diazinon and thimet.
SOURCE: Aldrin/dieldrin Suspension Hearing, Exhibit S-16 (5).

Table 14--Number of Corn Farms Using Insecticides on Corn, Major Corn States and U.S., 1973

Treatment	Ohio	Indiana	Illinois	Iowa	Missouri	Total (5 states)	Other States	U.S.
				Number of Farms				
Aldrin	7,567	7,303	17,093	19,586	9,519	61,073	9,305	70,378
Chlordane (Belt)	891	747	1,808	---	---	3,446	4,882	8,328
Heptachlor	---	---	3,607	3,684	---	7,291	1,763	9,054
Sevin	---	---	---	---	---	---	8,839	8,839
Other Carbamates	1,094	415	6,695	27,875	3,165	39,248	53,104	92,352
Phosphates	---	785	8,668	20,859	---	30,312	48,939	79,251
Other	2,441	798	2,352	5,442	1,647	12,681	957	13,638
Total Treating	11,256	10,244	38,468	62,561	13,917	136,446	105,161	241,607
Not Treating	43,413	47,832	51,279	54,879	31,933	229,336	499,080	728,416
TOTAL	54,669	58,076	89,747	117,440	45,850	365,782	604,241	970,023
				Percent of Farms				
Aldrin	13.8	12.6	19.0	16.7	20.8	16.7	1.5	7.3
Chlordane (Belt)	1.6	1.3	2.0	-	-	0.9	0.8	0.9
Heptachlor	-	-	4.0	3.1	-	2.0	0.3	0.9
Sevin	-	-	-	-	-	-	1.5	0.9
Other Carbamates	2.0	0.7	7.5	23.7	6.9	10.7	8.8	9.5
Phosphates	-	1.4	9.7	17.8	-	8.3	8.1	8.2
Other	4.5	1.4	2.6	4.6	3.6	3.5	0.2	1.4
Total Treating	20.6	17.6	42.9	53.3	30.4	37.3	17.4	24.9
Not Treating	79.4	82.4	57.1	46.7	69.6	62.7	82.6	75.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE: Other carbamates principally include carbofuran and bux ten; phosphates principally include dasanit, dyfonate, diazinon and thimet. Items may not add to totals because some farms applied more than one of the pesticides.
SOURCE: Aldrin/dield.in Suspension Hearing, Exhibit S-16 (5).

Costs of C/H and Alternative Controls

Insecticide ingredient costs for corn soil treatments are generally \$1.50 to \$5 per acre depending on whether broadcast or row treatment is used and which chemical is applied. These costs are a relatively small portion of the overall corn budget and value of the corn crop. At \$3 per bushel for corn and a yield of 100 bushels per acre (which is typical in corn growing areas where many of the insecticides are used), insecticide costs equal less than two percent of the value of the crop.

Table 15 includes a summary of insecticide costs per acre for typical applications to control corn soil pests in major midwest corn producing states (prices current as of 1974). Broadcast application generally costs twice as much as row (band or furrow) application because of higher rates of active ingredient applied. For example, band treatment for cutworms with chlordane would cost \$1.45/acre compared with \$2.90 for broadcast treatment due to a doubling of the application rate (Table 15).

C/H and aldrin are roughly half the cost of other pre-emergence controls such as diazinon. However, rescue treatments for cutworms such as Sevin (carbaryl) and Dylox (trichlorofon) are in the same cost range as C/H. These rescue treatments are less expensive than broadcast aldrin or C/H treatment by \$1 to \$2 per acre. Also, they are not applied unless needed, which lowers costs to the farmer. Limited data are available on added costs of scouting to use rescue treatments effectively. However, scouting costs should be nominal inasmuch as scouting can, in many cases, be accomplished at little added cost in connection with other field operations, such as cultivation and routine observation of growing crops.1/

Row treatments of corn insecticides do not involve a separate field operation, as the insecticide is applied with an attachment to the corn planter. The only added cost is for this attachment. Broadcast treatment may involve a separate field operation, thus adding fuel and other costs to producing the crop, possibly reducing the popularity of broadcast treatment.

1/ Scouting is discussed in more detail in Section V of the report.

Table 15--Insecticide costs for typical corn soil pest application in midwest, 1974

Target pest/ Method/Chemical	Formulation	Rate/acre	Cost/acre
Cutworms and wireworms (also grubs)			
Broadcast			
Aldrin	4#/Gal E.C.	2 qts.	$ 3.98
	20% G (granules)	10 lbs.	3.20
Heptachlor	20% G	10 lbs.	2.90
Chlordane	33% G	12 lbs.	3.60
	72% E.C.F.	2 qts.	4.45
Diazinon	14% G	14-28 lbs.	7.35
	Ag 500	2-4 qts.	15.00
Sevin (cutworm)	5% bait	10-20 lbs.	2.70
Dylox (cutworm)	4#/Gal.	1-2 pts.	1.90
Dyfonate	4#/Gal. E.C.	2-4 qts.	10.30
Band			
Aldrin	4# E.C.	1 qt.	$ 1.98
	20 G	5 lbs.	1.60
Heptachlor	20 G	5 lbs	1.45
Chlordane	33% G	6 lbs.	1.80
	72% E.C.F.	2 pts.	2.25
Diazinon	14 G	7-14 lbs.	4.90
	Ag 500	1-2 qts.	7.50
Sevin (cutworm)	80% S.P.	2-5 lbs.	2.25
Sevimol (cutworm)	4#/Gal.	1/2 Gal.	3.20
Western Rootworm (Band)			
Furadan 10G	7.5 lbs.	9 ozs.	$ 3.30
Thimet 15G	6.5 lbs.	8 ozs.	2.50
Dyfonate 20G	5 lbs.	6 ozs.	2.85
Modcap 10G	10 lbs.	12 ozs.	3.20
Dasanit 15G	6.5 lbs.	8 ozs.	2.85
Diazinon 14G	7 lbs.	8.5 ozs.	2.60
Diazinon 50W	1-2 lbs.	1.25-2.5 ozs.	4.50
Bux 10G	10 lbs.	12 ozs.	3.80

SOURCE: Theordore Riedeburg Associates, Pesticide Use for Control of Soil Borne Insects in Corn in the States of Indiana, Illinois, Iowa and Missouri, November 1974.

Production Impacts of C/H and Alternative Controls

This section summarizes available data on the yield and production impacts of using C/H vs. alternative controls for rootworms, wireworms and cutworms.

Production/yield benefits of the use of a given pesticide treatment depend on two critical factors:

(1) efficacy of the treatment in controlling the target pest

(2) the level of infestation

Pesticides generate maximum benefits when they are highly effective in controlling the pest and when infestation levels are high. This section summarizes available information on the yield impacts of alternative controls taking into account these two factors.

Unfortunately, estimation of yield benefits from the use of alternative pesticides is not at all a precise process because levels of infestation vary greatly from year-to-year and from area-to-area, even though efficacy and use patterns may be more stable.

Ideally we would be able to make precise point estimates of yield and production impacts of a cancellation. However, because of data limitations and because of year-to-year variations in economic, weather, and infestation conditions, this is not feasible. We are left with only the option of making estimates of the range of possible effects--hopefully covering the range of best-case to worst-case outcomes. Even if a very precise and accurate estimate is made for a given year, one cannot be sure how such a year compares with other years. The data presented in this section provide the basis for making worst case estimates of impact which are presented in a later section. Studies are in process to develop necessary data on infestation levels and yield effects with alternative controls such that a typical or average case outcome can be analyzed as well.

Rootworms

The recommendations of the states reflect the general view of entomologists that rootworms are better controlled with nonorganochlorine insecticides or by crop rotations, avoiding corn following corn. Accordingly, it is likely that there will be some increase in yields as alternates to aldrin are used to control rootworms. As of 1971, 4.7 million acres were being treated with aldrin for rootworms (12). No doubt some C/H treatments were also aimed at rootworms at that time and may still be targeted at them.[1]

Inasmuch as alternative controls do a better job than chlorinated hydrocarbons, shifting to one of these will increase yields on a given field or reduce chances of damage from field-to-field or from year-to-year. Illinois data suggest yield increases from alternates in control of rootworms (15). This is consistent with reports obtained in 1973 from entomology department chairmen in universities of major corn producing states. This survey, conducted by USDA, indicated that increased yields of up to 10 bushels per acre on those acres treated for resistant rootworms would result from going to nonorganochlorine alternates in states of Iowa, Wisconsin, Missouri, Indiana and Illinois (16).

As an example, Turpin and Matthews estimate that in 1974 about 250,000 acres planted only to corn each season were treated with aldrin in the northern third of Indiana where the western corn rootworm is established (17). They estimate that the minimum loss in Indiana on uncontrolled infestations of western corn rootworms is 5 bushels per acre. Therefore, if organophosphate or carbamate insecticides were used on those acres, there would be a saving of 1,250,000 bushels (17).

The potential for increased yields from nonorganochlorine alternatives for rootworms was also recognized by Delvo in 1974 (12, p. 6).

Wireworms

Wireworm yield effects tend to be spotty and most likely to occur in corn rotations following sod, pasture or idle acres. The spotty nature of wireworm problems was suggested by Munson (Missouri Survey Entomoligist) who stated that wireworms are not much of a problem in the state and are limited to relatively few counties.[2] The sporadic nature of infestation frustrates the effort to target pesticide application so that economic returns cover the cost of treatment. Production impacts from the lack of organochlorine controls have been estimated variously from increased yield, to no effect, to yield reduction of 5 or more bushels per acre. In a USDA survey in 1973, yield impacts as follows were estimated by state entomologists: (Iowa, 5 bu.; Wis., 4 bu.; Nebr., not known; Ind., not known; and Ill., +5 bu.) (16). A survey of state entomologists and other professionals, conducted by EPA in 1973, resulted in no specific estimates of yield reduction due to use of nonorganochlorines on wireworms.

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[1] According to one survey, as of 1971, 262,000 acres out of 669,000 acres of corn treated with heptachlor were treated for rootworms (39%) (29).

[2] In May, 1974, Munson met with Arnold Aspelin and Fred Hageman of EPA, who were on a field trip to Missouri. At that time, a map was prepared showing that infestations are limited largely to a 12 county area in the S.W. portion of this state and even there they are "spotty".

Delvo contacted experts in the major corn growing states in 1973 to obtain estimates of yield impact from cancellation of organochlorines (12). He estimated no yield effects from alternatives for control of wireworms in Ohio, Indiana, and Illinois. He did estimate an 8 percent reduction in Iowa, Missouri and certain other unspecified Lake States and Northern Plains States, assuming alternatives are used under moderate to heavy outbreak conditions as compared to control under the same conditions by organochlorines. These predictions seem rather extreme considering the history of losses in these states. A loss of 10% on the average for organochlorine-treated acres with 33% loss implies 33% of the acreage suffers that average level of damage (i.e., 33% of acreage x 33% loss = approximately 10% loss in production). This is unlikely to occur, judging from historical records on wireworm and other pest cost and pest infestations during the last 25 years.[1]

For some species of wireworms, the necessity for organochlorines is also questionable based upon conversations with senior entomologists and on information from states, including their published recommendations. There is a likelihood that aldrin (or heptachlor) will fail under heavy outbreak conditions as indicated in the 1974 Missouri Recommendations (p. 55). In Iowa, Stockdale and Owens disagree as to the efficacy of aldrin and question whether it is needed to control wireworms, thus raising the same issues relative to C/H (18).

Recent test data from Illinois, Iowa, Indiana and North Dakota further indicate that certain organophosphate and carbamate alternatives are as effective as organochlorines in wireworm control.(32)[2]

Another dimension to the wireworm problem is that its life cycle is three or more years which makes it possible to achieve reduction in pest populations without treatment each year. Three year crop rotation and/or treatment schedules can reduce wireworm pest problems (19).

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[1] Review of pest infestation/damage under USDA's Cooperative Economic Insect Report Program for the midwest states for the last 25 years and review of weekly pest reports by the Department of Entomology, University of Missouri for the last 10 years (Review by Fred Hageman, EPA entomologist).

[2] Field tests in Illinois in 1975 (personal communications from Luckmann, August 1975) indicate that carbofuran applied in the furrow will control wireworms.

Cutworms

Aldrin and heptachlor are still effective for cutworm control even though we cannot assume that aldrin, or any chlorinated hydrocarbon, will always reduce cutworm damage to less than economic levels. For example, extension entomologists from Missouri, a leading state in cutworm problems, cautioned farmers in 1972 that aldrin, heptachlor and chlordane applications "made at or prior to planting have not given desired results against cutworms in some instances" (20). They warned producers that a rate of 1 lb a.i. in row treatment, a common practice, does not give acceptable cutworm control. Tillage and rainfall factors were also cited.

Turpin reported that of 5 fields which had reported black cutworm infestation during 1972 and 1973, all of which had a moderate to severe problem, 3 had not been treated and 2 had been treated with aldrin, one by band and one by broadcast application (32).

Petty stated:

> "The more serious problem of the black cutworm is not completely corrected by the use of chlorinated hydrocarbon pesticides, as evidenced by the fact that county Extension advisers received over 90 complaints of cutworm damage in 1972 in fields in which aldrin, heptachlor and chlordane were used" (32).

In addition, the cutworm damage in corn fields in the Missouri bottomlands where aldrin is reported to be used by the vast majority of farmers would seem to indicate that aldrin is either being misapplied and/or is not effective enough to prevent injury under pressure of high populations.1/

Yield impacts were limited if they occurred at all when aldrin was denied to dairy farmers in Missouri for protecting corn against soil pests -- according to Keaster and Munson, state entomologists, and Taylor, a regional farm management specialist (21).

Cutworm damage, in terms of dead plants, can range to near 100% in extreme cases. Luckmann observed damage in certain parts of fields in

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1/ Hershell Gaddy, regional extension agronomist in a three county high risk - bottomland area in Missouri, indicates that 20 to 25% of corn land must be replanted each year due to all causes, including cutworms and the serious problems of flooding. Much of it is treated with organochlorines like aldrin and heptachlor but often in furrow or band which does not control cutworms well.

1974, ranging from 6 to 85%, averaging 28% in the hot spots among 15 fields with damage (6). According to Gaddy, a reduction in stand of 17% will reduce yield by 15% on Missouri bottomland (19). He also indicates that a reduction in plant population of 35 to 40% may result in replanting of corn or possibly planting of soybeans if the farmer has not used an organochlorine. One disadvantage of using a pre-emergence organochlorine insecticide in a high risk area is that soybeans cannot be planted should the corn stand be lost to insects, flood or other factors. An identical estimate was made by Thomas, extension entomologist, University of Missouri.1/ No doubt some cutworm damage can occur without reduction in yield as some plants will regrow after being damaged and the loss of plants leaves more water and nutrients for nearby plants.

A comparison of aldrin-treated and nontreated areas of 13 bottomland fields in 6 Missouri counties indicated a yield differential of 7.93 bushels in favor of aldrin (120.69 vs. 112.76), an increase of about 7% yield while the plant population averaged only 3.5% higher (17,538 vs. 16,942)(Appendix A, Table 2). This test was done on farm cooperator fields in bottomland areas. Although this test is not based on a large statistical sample, it gives an indication of average yield improvement under field conditions, compared to no treatment. Unfortunately, data were not available on the extent of infestation nor on any other alternative insecticides. Entomologists in Missouri indicate that research devoted to estimating yield improvement due to C/H and alternatives has been frustrated by lack of test areas with infestations of cutworms.2/

Key issues in estimating the impacts of shifting to alternative cutworm controls are the level of damage during an infestation and the probability or frequency of infestation. Let us now turn to the latter.

Infestations of cutworms are quite sporadic, although they tend to follow flooding and standing water, either during the current year or from the previous year. The result is that even on the most risky cutworm land, one cannot expect to have a serious economic infestation in a given area more than 2 out of 5 years (22). Similar frequencies are indicated in the 1974 Missouri insect control recommendations where treatment is recommended on soils subject to annual or frequent infestations (3 out of 5 years) and on first year corn after sod (23).

1/ Meeting with G.W. Thomas of University of Missouri and A. Aspelin and F. Hageman of OPP, EPA in May, 1974, in Columbia, Mo.

2/ Letter from Armon Keaster, Entomologist, University of Missouri, to Arnold Aspelin, EPA, 1974.

According to Fairchild at the aldrin/dieldrin cancellation hearings, "...a high risk field for cutworms...is one where we believe that, for one year in three, failure to treat will result in significant production loss" (24). Presumably, all other fields would have less frequent losses.

Petty testified that cutworm damage at economic levels would not be expected to occur in more than 3 or 4 years out of 10 in the high risk area of Illinois (25).

In 1974, in response to a concerted effort by researchers on the corn soil arthopod research project to locate cutworm problem fields in the midwest, Turpin reports that very few significant infestations of black cutworms were found. The number of problem fields per state is as follows:

Indiana	16
Illinois	15
Missouri	4
Ohio	3
Iowa	9
Nebraska	0

Damage level varied from 2% plant reduction to the need to replant in three instances. A few of these fields were treated with chlorinated hydrocarbons (26).

An estimated 30 to 40% chance of infestation in high risk areas is confirmed by the previously mentioned research results in Missouri on 13 bottomland test fields (Appendix A, Table 2). Five of the 13 fields showed a yield improvement from treatment of more than one bushel per acre (38%). The treated fields averaged 3.5% greater stand count, with treatment, as 5 fields had an improved stand of more than 500 plants per acre.

Based on the above views and data, it seems that no more than one third of the corn fields treated for cutworms with organochlorine would suffer heavy cutworm damage in a typical year, if not treated.

Delvo of USDA, based on his survey of state entomologists in 1973, indicates the following percentage yield reductions from cancelling organochlorines to control cutworms on 1971 aldrin acreages (30).

	With use of alternatives	Without use of alternatives
	percent	
Ohio	-5	10
Indiana	-10	25
Illinois	-10	25
Iowa	-10	25
Missouri	-15	30
Lake States & Northern Plains	-10	25
Other states	0	0

The Delvo report shows much higher yield improvement from treatment of cutworms with organochlorines in Missouri than can be justified on the basis of the only known Missouri field test on actual commercial farms (Appendix A, Table 2). The yield improvement of 7.93 bushels per acre on the 13 fields is appropriately compared with the 30% loss figure for Missouri in the Delvo study, where no alternative insecticide was assumed to be used. The Delvo study calls for an impact more than four times larger than the empirical data indicate. Although 13 fields do not constitute a large statistical sample, these results suggest that Delvo's yield impacts are very high, more than one would expect to occur even in a moderate to heavy infestation. Surveys of state entomologists by EPA and USDA, conducted in 1973, indicated yield reductions due to control of cutworm with nonorganochlorines in the range of 5 to 10 bushels per acre (16) (27).

Economic Impacts of Cancellation

Presented in this section are the results of a linear programming analysis for U.S. agriculture indicating impacts of the C/H cancellation during the period 1975-80, on a typical year basis (1977).[1/] This section also summarizes results of earlier economic studies conducted on the impact of cancelling chlordane and heptachlor, including one study done on the impact of cancelling aldrin which relates also to the C/H cancellation. These earlier studies include estimates of impact on the year 1971.

Earlier Studies

Staff members of the U.S. Department of Agriculture have prepared brief economic impact analyses of the effects of discontinuing farm use of chlordane (28) and heptachlor (29). The USDA report on chlordane indicates there would be no yield impact, from the withdrawal of chlordane, on 210,000 acres assumed to be treated with chlordane in 1971. It was assumed that a combination of diazinon plus carbaryl at 2 pounds per acre each would yield results comparable to chlordane in the control of corn pests. Two pounds of active ingredient of each of these pesticides was used as basis for computing differences in cost of chlordane. The result was a cost of $8.80 per acre compared with $2.03 per acre for chlordane, generating a total cost impact of $1.4 million (210,000 acres x $6.77 per acre). The results of this analysis are of limited value at this time for the following reasons:

1. The acreage of corn treated with chlordane is thought to be as much as four times the acreage shown in the USDA study (812,000 acres in 1973 as shown in Table 11 above in contrast with USDA's estimate of 210,000).

2. Costs of the alternatives of $8.80 per acre are excessive as compared with those in Table 15.

The heptachlor report (29) includes estimates of cost and yield impact of non-organochlorine alternatives to heptachlor for the year 1971. A total of 669,000 acres were assumed to be treated with heptachlor for corn soil insects, mainly in the state of Illinois (262,000 acres for rootworms and 407,000 acres for other soil insects). No yield impacts were assumed for rootworm control but a yield reduction of two bushels per acre was assumed for the 407,000 acres where soil insects are a problem. The result was a reduction in corn production of about 800,000 bushels, mostly in Illinois but with some reductions in Missouri, Minnesota and other states. The reduction in corn production of 800,000

[1/] This analysis of impact is based on worst case assumptions of impact. Another analysis of impacts with typical or average yield and cost effects will be completed in the near future.

bushels amounts to a 0.014% reduction in production for the year 1971 (based on total production of 5.6 billion bushels in the U.S.). The reduction for the state of Illinois estimated to be 500,000 bushels amounted to a 0.047% reduction in production (based on total production of 1.067 billion bushels). Increased costs for alternative controls were estimated at $1.55 per acre for rootworms and $1.73 per acre for other soil insects giving a total cost impact of $1.11 million.

Estimated corn acreage treated with heptachlor in ERS's heptachlor cancellation impact analysis -- 669,000 acres for the year 1971 -- is inconsistent with USDA's 1971 Pesticide Use Survey which indicates that heptachlor was used on 1,901,000 acres. (see Table 12 above). If adjustment is made for the difference in acreage, and distribution of acreage treated for rootworms and other soil insects is maintained, the impact is increased by approximately 2.8 times or to 0.04% of the U.S. production, i.e., about 2.5 million bushels. It is not known whether such a transformation is entirely appropriate; it is included here only for illustrative purposes.

Impact of C/H and Aldrin Cancellations: 1975-80, Typical Year Basis

This section of the report presents results of a linear programming analysis of the U.S. agricultural sector focusing on the impacts of the combined cancellation of aldrin, chlordane and heptachlor for use on corn during the period 1975-80, typical year basis. The year 1977 is selected for purposes of presenting results of the cancellation. The approach is to evaluate impacts of the cancellation by comparing a base solution which reports an equilibrium agricultural sector for the year 1977 and a solution with the cancellation of aldrin, chlordane and heptachlor with resulting impacts on acreage production and income for agricultural crops in the U.S. The model consists of crop activities for 127 production regions which are aggregated into 27 consuming regions for which final demands are specified. Seven crops (irrigated and dryland) are endogenous to the model: barley, corn, cotton, soybeans, oats, sorghum, and wheat. The model allocates acreage to these crops in the various regions in optimum least-cost manner as operators employ land in the use which yields the greatest return. In the base solution separate activities are included for corn produced with no insecticides, with insecticides other than organochlorines and with organochlorines. Land is used for these alternative approaches according to type (i.e., whether or not infested with soil insect pests, land class, etc.) and according to profits from alternative approaches to raising corn in competition with other crops. The alternative solution differs from the base solution by eliminating the cancelled organochlorines. Cancellation leaves open the possibility that land previously treated with those chemicals will remain in corn production, with or without alternative insecticides. The land may also be shifted to an entirely different crop or become idle, possibly under a Government program.

The model attempts to simulate how impacts of a restriction will unfold after a period of adjustment has been permitted to occur and a new equilibrium is reached. This type of analysis is preferred to the more routine procedure of estimating yield and cost impacts on fixed acreages at state and regional levels because shifts in yields and costs of a particular crop have impacts not only on that crop but also alternative crops which may be grown in its place. For example, a given type of land in a region may suffer a 10% reduction in net returns as a result of a cancellation. This may shift that land to the production of another crop. This means that other land will be brought into use in order to maintain production. A more detailed discussion of the logic and parameters of the model is presented in Appendix C.

Estimates of corn infested with wireworms, rootworms, and cutworms were based upon data presented at the aldrin/dieldrin hearings on the number of farms and acreage estimated to be infested for the year 1973. These data presented at the state level were allocated among the appropriate 127 regions. Costs of alternative pesticides are projected forward to be representative of costs as of 1977 from a base of 1973 costs.

Yield impacts of cancellation were developed by Delvo for a moderate to heavy infestation year (12). Delvo, as discussed earlier in this report, estimated yield reductions at two levels: a) with the use of alternatives and b) without the use of alternative controls. Delvo's estimates of impact on yield were supplemented by an additional assumption that land infested with rootworms would generate 8% higher yields if alternatives to organochlorines were used. Delvo had assumed that no increase in yield would occur, although he recognized the possibility that yields could increase from the use of alternatives on rootworm infested land (12).

Solution Impacts

In this section we have not attempted to report all details of impacts associated with a C/H restriction as set forth under the preceding assumptions. Rather, the primary impacts will be reported. It should be pointed out that, while impacts will be reported here on a aggregative basis, e.g. acres of corn per state or regions, the model solution shows impact by soil (irrigated, nonirrigated or fallowed) within a region.

On a national basis, the model solution shows an aggregate increase of 200,000 acres planted to corn. This results from the fact that corn, even at slightly reduced yields, is still a more desirable feedstuff than alternative feedgrains; farmers would increase their planting slightly to offset minor yield reductions. Total changes in land use are reported in Table 16. Slack or idle cropland (reported in the last column of Table 16) is reduced by 1,160,000 acres. This means that in total, 1.16 million acres more cropland would be in production following a C/H restriction in 1977 than would be used if C/H remains available. Again, the logic associated with this outcome is found in the farmers' willingness to plant slightly more acres of feedgrains in general to replace corn in particular. This change amounts to approximately a 3.7% reduction in slack or idle land between the two solutions.

As a welfare concept, the model reports total returns to the land (net of variable operating expenses). In general, economic theory suggests that actions which tend to constrain the agricultural sector, with an overall inelastic demand for agricultural products, will lead to price increases which more than offset the income effects of decreased production. The overall impact is higher total returns and higher aggregate profits. The results of the comparative models are consistent with this theory.

As shown in Table 17, the net returns to land for all endogenous production activities in all regions increase by slightly more than $71 million. The distribution of this increase varies by region and production alternative; but, on a national level the directional change is unambiguously positive. The only negative entries in the U.S. total column of Table 17 are for chlorinated hydrocarbon corn activities, signifying the reduced returns to land from these activities after cancellation or alternatively, the returns which these activities generated prior to cancellation. On a percentage basis, the C/H cancellation results in increased returns to corn production in the corn belt ranging from 4.4% to 23.4% and an overall 2.15% increase in returns to land in general (U.S. total).

Table 16--Net impacts on land use resulting from C/H restriction on corn, by aggregate U.S. subregions, 1977

Region	Barley	Corn	Cotton	Soybeans	Oats	Sorghum	Wheat	Slack
	--------------------	--------------------	--------------------	--------millions	of acres--------	--------------------	--------------------	--------------------
North East	0.00	0.01		0.00	0.00	.	0.00	.
South East	0.00	0.39	0.01	-1.26	.	.	0.01	-0.14
North Central	0.16	-1.49	.	1.04	-0.01	0.09	-0.07	0.29
South Central	.	0.20	0.00	-0.01	.	0.23	0.01	-0.43
Mtn. & Gt. Pl.	0.01	1.07	0.07	-1.16	0.26	0.07	0.50	-0.85
North West	.	0.01			.		.	-0.03
South West	0.00	0.00	.		.		0.00	.
U. S.	0.17	0.20	0.08	-0.40	0.25	0.40	0.45	-1.16

0.00 = less than 5,000 acres
. = zero
No entry = nonactive production alternative
Columns may not total to U.S. total due to slight rounding errors

Source: EPA linear programming analysis.

Table 17--Changes in net returns to land resulting from C/H restriction on corn by production alternative, aggregative U.S. subregions, 1977

Production Activity / Region	North East	South East	North Central	South Central	Mtn. & Gt. Plns.	North West	South West	U.S. Total
	----------	----------	----------	-millions	of dollars-	----------	----------	----------
Barley, Dryland	0.14	0.01	1.49	0.08	0.68	0.02	0.01	2.43
Barley, Dryland, Fallow				.	1.55	0.13		1.70
Barley, Irrigated					0.83	0.10	-0.00	0.93
Corn, Dryland	2.29	1.05	1.02	0.05				4.40
Corn, Irrigated					6.88	1.68	4.96	13.52
Corn, Dryland, No Pesticides			79.44		19.68			99.12
Corn, Dryland, Other Pesticides			6.37		0.41			6.78
Corn, Dryland, C/H			-133.40		- 4.40			-137.80
Corn, Irrig., No Pesticides					2.61			2.61
Corn, Irrig., Other Pesticides					12.30			12.30
Corn, Irrig., C/H					- 7.29			- 7.29
Cotton, Dryland	-0.00	.	2.91	0.79				3.70
Cotton, Irrig.			- 2.90	4.31			0.84	2.25
Soybeans, Dryland	-0.01	1.53	46.99	0.01	-10.42			38.10
Soybeans, Irrig.								
Oats, Dryland	0.07	.	0.01	0.00	5.36			5.44
Oats, Dryland, Fallow				.	1.41	0.00	.	1.41
Oats, Irrig.					0.03		.	0.03
Sorghum, Dryland	0.00	.	1.67	1.98	4.24			7.89
Sorghum, Irrig.				3.90	- 0.90		0.17	3.17
Wheat, Dryland	0.37	0.09	- 3.45	0.37	2.40	1.25		1.04
Wheat, Dryland, Fallow					7.72	0.59	0.08	8.39
Wheat, Irrig.					0.58	-0.78	1.34	1.14
Total Value	2.87	2.67	0.15	6.38	48.80	2.98	7.40	71.25
Ave. Shadow Price, $/acre	0.51	0.29	0.08	0.17	0.35	0.26	2.42	0.24

Table Notes: 0.00 = changes of less than $5,000
 = no change

Source: EPA linear programming analysis.

Any modification of parameters such as yield per acre (as was assumed to be true with a C/H restriction) causes prior model solutions to be nonoptimal. Activity levels in prior solutions no longer represent least cost solutions and the model will therefore "search" for new activities which can reduce the overall objective function. Activity adjustments can take the form of production levels (acres within a region), transportation between regions, substitution of production between land classes (use of higher or lower yielding land within a production region) and/or substitution of one commodity for another in optimum feed mixes. All of these adjustments will lead to changes in total production within a region. Therefore, an examination of changes in production of the endogenous crops within regions provides both an indication of the severity of the impact as well as the overall level of the impact.

At the national level, the overall impact of the C/H restriction caused the following relative adjustments in the production of the endogenous crops: barley (+2.43%), corn grain (-0.70%), cotton lint (+0.02%), soybeans (-0.09%), oats (+3.90%), sorghum (+1.90%), wheat (0.2%). The absolute and relative changes for these crops are reported in Table 18 for seven aggregate subregions of the U.S.

Shifts in land use are a result of changes in comparative advantages and prices following cancellation. The major impact of these shifts can be evaluated at the national level by examining changes in production. In total, corn production is decreased by 36.9 million bushels (0.70% of base production). This reduction is offset by increased production of barley (8.56 million bushels), oats (11.61 million bushels), grain sorghum (20.55 million bushels) and wheat (3.54 million bushels). While the overall reduction in corn production is modest at the national level, some regional adjustments are quite significant. For example, equilibrium adjustments in the North Central region total to 194 million bushels of corn (approximately 1.5 million acres). This was the largest single adjustment in corn production (6% of base model production). Clearly, this represents a major change in production patterns and would result in major adjustments in land use. From Table 16 it can be seen that most of the equilibrium adjustments occur by substituting soybean production for corn production (1.04 million acre increase in soybeans for a 1.49 million acre decrease in corn). However, in the North Central region there is an increase of 290,000 acres in idle land. In addition, 160,000 additional acres of barley and 90,000 additional acres of grain sorghum are produced. After all adjustments in the land base of the North Central region have occurred, 140,000 additional acres of cropland are brought into production. Resulting income adjustments, as depicted in the "North Central" column of Table 17, result in a very small increase in net returns to land of $150,000 in aggregate.

Further adjustments occurring in the North Central region (although not reported completely in this section) show an increased transportation of corn into the North Central from other regions of the U.S., equalling

Table 18 -- Absolute and relative change in production of endogeneous crops as a result of C/H restriction, by aggregate U.S. subregions, 1977

Region	Commodity						
	Barley bu.	Corn Grain bu.	Cotton Lint Bales	Soy-beans bu.	Oats bu.	Sorghum grain bu.	Wheat bu.
	-millions of units (%)-						
North East	*	0.56 (0.18)	0	-0.04 (-0.28)	0.04 (1.07)	*	-0.21 (-0.5)
South East	0.09 (8.12)	23.80 (12.63)	0.01 (6.39)	-6.04 (-5.15)	0	*	+ .14 (+1.3)
North Central	7.90 (44.85)	-194.2[illegible] (- 6.00)	0	38.60 (3.21)	-1.01 (-2.90)	7.83 (11.48)	-2.59 (-1.9)
South Central	0	15.69 (88.61)	-0.05 (-0.93)	-0.62 (-0.27)	0	15.13 (7.18)	.4 (0.6)
MTN & GT. PLNS.	0.65 (0.25)	115.68 (8.78)	0.03 (0.54)	-33.62 (-11.09)	12.64 (4.88)	-2.42 (-0.31)	5.88 (0.6)
North West	*	1.19 (6.14)	0	*	0	0	.07 (0)
South West	-0.08 (-3.07)	0.44 (0.24)	0	*	*	0	- .17 (-0.2)
U.S. Total	8.56 (2.43)	-36.91 (- 0.70)	*	-1.17 (-0.09)	11.61 (3.90)	20.55 (1.90)	3.54 (0.2)

* - Less than 5,000 units

Source: EPA linear programming analysis.

171 million bushels. As a result, although gross production of corn in the region is reduced by 194 million bushels, feeding of corn to meet livestock demands within the region is reduced by only 22 million bushels. Sorghum grain is the main substitute feedgrain and is increased by 24 million bushels. Sixteen of this 24 million bushel increase in sorghum is supplied via interregional trade.

In general, while examination of any one region, commodity or parameter in the model might reveal major adjustments and/or impacts associated with the C/H restriction, the overall evaluation of the national model suggests minor adjustments which the agricultural sector can respond to. In addition, it must be kept in mind that these solutions depict the consequences of a C/H restriction assuming extreme impacts.

The reduction in U.S. corn output of 36.9 million bushels (0.70) is within the range of estimates made Delvo for cancelling use of aldrin with and without the use of alternatives. His estimate of impact, using nonorganochlorine alternaitves on wireworm and cutworm land, was 21.1 million bushels; without alternatives, it was 55.1 million bushels (0.4 to 1.1%). The estimate of 36.9 million bushels based on the linear programming analysis is equal to the low end estimate resulting from a 1973 review of possible impacts of the combined aldrin, heptachlor and chlordane cancellation in the states of Ohio, Indiana, Illinois, Iowa and Missouri. 1/ In that review, the production loss was estimated to occur within the range of 34.9 - 84 million bushels in only those five states. Taking into account the remaining states which would have suffered some production losses, this review places the minimum range of possible production losses somewhat above the linear programming analysis worst case estimates.

The corn production impacts of the C/H cancellation can be brought into perspective by viewing them within the context of year-to-year variations in corn production in the United States. Presented in Figure 1 are time series data on production of corn in the United states for the period 1962-1974 and year-to-year changes charted on a zero axis to more clearly visualize the variability of production of corn in the United States due to all factors. 2/ Since 1962, corn production has varied from a low of about 3.5 million bushels to more than 5.5 billion bushels with year-to-year changes of as much as 500 million to 1 billion bushels. The impact of 36.9 million bushels is nominal by comparison with year-to-year changes to all factors impacting on the production of corn in the United States. It is dwarfed by the precipitous decline in production in 1974 and by the large drop in production in 1970 attributable largely to the corn blight.

1/ Report entitled "On-Farm Effects of Aldrin, Heptachlor, and Chlordane Cancellations for Corn," by Ralph Freund, Economist, Office of Pesticides, EPA, August, 1973.

2/ Figure 1, presented in Part II of this document, page 165.

Comparison of C/H and Aldrin Impacts

Presented in Table 19 are additional data on the impacts of cancellation at the national level, with a rough breakout of impact attributable to C/H and those attributable to aldrin. Allocation of impacts between the C/H cancellation and the aldrin suspension is on the basis of 1973 acreage of corn treated with the three chemicals (18.7% C/H and 81.3% aldrin). Because of substitution of one chemical or another, a procedure such as this is needed to appropriately attribute the impact to one or the other action.

The apportionment of production impacts between the two actions is 6.9 million fewer bushels for C/H and 30.0 million fewer for aldrin (total of 36.9 million). In percentage terms, the production impacts are: C/H - 0.1%; aldrin - 0.6% and total -07%.

Acres of cropland used for the seven crops increased by 1.16 million, of which 217,000 acres was due to C/H. For corn, the reduction in corn acres was only 37,000 acres--out of the total 200,000 acres for C/H plus aldrin.

The LP model indicated a 2.6% increase in the price of corn (0.5% for C/H alone). This figure is larger than one would expect based on time series price analysis coefficients in which it is generally recognized that a 1% decline in the production of corn results in a 1.5% increase in price. A reduction in production of 0.7 percent would indicate a price increase of only 1.05% (1.5 x 0.7). The higher price effects in the model solution are due to the assumption that U.S. demands for protein and total digestible nutrients from feed grains are fixed in the model, thus generating a more inelastic demand than is observed through time series estimation.

Interregional grain transportation costs increase slightly in percentage terms (0.9% for corn and 0.5% for the seven crops combined) and by $3.74 million and $6.36 million, respectively (Table 19). These increases are attributable largely to the assumption maintained in the model that total regional demands for livestock feed are fixed, whereas in practice one would expect movement of livestock feeding to areas near feed production in case of regional change in feed grain production.

Table 19 -- Impacts of proposed cancellation; apportioned into C/H and aldrin, focus on corn, other grains and cotton, U.S. economy 1975-80, 1977 typical year

Item	Unit	C/H	Aldrin	Total
Corn acres treated (1973)	1,000 acres	1,713	7,448	9,161
• • • •	Pct.	18.7	81.3	100.0
Change due to cancellation (cancellation solution minus base solution)				
A. Acres of corn grown with:				
1. No pesticides	1,000 acres	1,040	4,510	5,550
2. Other pesticides	1,000 acres	26	1,140	1,400
3. Org. chlorines	1,000 acres	-1,400	-6,080	-7,480
4. Other	1,000 acres	140	590	730
Total	1,000 acres	37	163	200.0
	(Pct.)	(0.7)	(3.3)	(4.0)
B. Corn production	1,000 bu.	-6,901	-30,009	-36,910
	(Pct.)	(-.1)	(-.6)	(-0.7)
C. Acres of cropland in use				
Corn	1,000 acres	37	163	200
Barley	•	32	138	170
Cotton	•	15	65	80
Soybeans	•	-75	-325	-400
Oats	•	47	203	250
Sorghum	•	75	325	400
Wheat	•	84	366	450
Total	•	217	943	1,160
D. Price of crop				
Corn	Pct.	0.5	2.1	2.6
Barley	•	0.3	1.2	1.5
Cotton	•	0.1	0.7	0.8
Soybeans	•	-0.1	-0.2	-0.3
Oats	•	0.3	1.4	1.7
Sorghum	•	0.5	2.0	2.5
Wheat	•	0.1	0.5	0.6
E. Grain transport cost				
Corn	$million	.70	3.04	3.74
Other	•	.49	2.13	2.62
Total	•	1.19	5.17	6.36
F. Returns to land - change in dollars	$million			
Corn	•	-1.19	-5.17	-6.36
Barley	•	.95	4.11	5.06
Cotton	•	1.11	4.84	5.95
Soybeans	•	7.11	30.89	38.00
Oats	•	1.29	5.59	6.88
Sorghum	•	2.07	8.99	11.06
Wheat	•	1.88	8.19	10.07
Total	•	13.32	57.92	+71.25
G. Returns to land - change in percent	Percent			
Corn	•	-.1	-.5	-0.6
Barley	•	1.1	5.0	6.1
Cotton	•	.3	1.4	1.7
Soybeans	•	.8	3.4	4.2
Oats	•	2.5	10.8	13.3
Sorghum	•	.8	3.4	4.2
Wheat	•	.4	1.5	1.9
Total	•	.4	1.8	2.2

Source: EPA linear programming analysis.

The increase in returns to land due to the combined aldrin and C/H cancellations is $71.25 million, of which $13.32 million is due to C/H cancellation (Table 19). The corn sector has a net reduction in returns to land at the national level of $6.36 million (-0.6%) as a result of the cancellations, of which $1.19 million is attributed to C/H. Returns to land for the seven crops combined increased by 2.2% (0.4% due to C/H and 1.8% for aldrin).

Impacts on Food Production Costs and Expenditures for Food at the Consumer Level

The linear programming model estimated changes in the agricultural economy as a result of the proposed C/H cancellation. Price levels of the endogenous crops generally increased as substitution of one crop for another took place, although the price of soybeans declined. In Table 19, the percent change in the price for individual crops is shown and they vary from -0.3% for soybeans to 2.6% for corn. In addition, the model simulates the cost of producing meat and poultry products and nonmeat foods. Most of the increased costs occur in the corn and feedgrain sectors which directly affect the cost of producing red meat and poultry on grain intensive rations.

To estimate impacts at the consumer level in response to changes in production costs at the farm level, it is assumed that all increases in the prices of endogenous crops and increases in meat and nonmeat commodity prices are passed on to the consumer. This is consistent with the preconditions or restrictions built into the linear programming model that an equivilant quantity of food would be demanded and therefore supplied before and after the cancellation decision.1/

The linear programming model was run for a typical year and 1977 was chosen to estimate expected annual costs. In the estimation of impacts all values of relevant variables are projected for 1977.

The model provided an estimate of $364.8 million as the change in the production level cost for 1977. This estimate includes all cost increases which result from the cancellation, e.g., the impact of higher prices, changes in production costs and/or yields, changes in transportation costs, etc.2/ The $364.8 million impact is based upon worst case assumptions and represents the maximum amount that expenditures for food would be expected to increase.3/

1/ The implicit assumption is that consumer demand for food is not affected by the cancellation (demand is completely inelastic).

2/ The model converts feedgrains into corn equivalents. To project price levels for all crops it was necessary to predict corn price for 1977. A linear trend regression estimated price at $2.50 per bushel and this price is used to represent costs in 1977.

3/ Food prices would not exceed this dollar amount because the C/H cancellation is at the farm level of implementation which is highly competitive. Available evidence is that cost changes at the farm level are passed on to the consumer by the amount of change in cost.

Consumer expenditures for food in the most recent year were $164.5 billion. The percent of disposable personal income (income net of taxes) spent for food in 1974 was 16.8% (31). In the past ten years it has averaged 16.66% and the average variations for this period of time has been less than one percent. Expenditure for food were projected out to 1977 using a linear trend regression, based upon data in the previous 10 years. The regression predicted a total expenditure of $191.04 billion.

In relation to the C/H cancellation, the impact is equal to 0.19% increase in price for all food expenditures. For meat products depending on large quantities of feed grains price impacts are expected to range between .4 and .5%. Using a U.S. population estimate of 215 million for 1977, the C/H cancellation amounts to an annual $1.70 per capita, when analyzed with worse case assumptions.

Conclusions on LP (Linear Programming) Analysis

The foregoing analysis indicates significant differences in economic variables during the 1975-80 period, with and without C/H and aldrin, under worst case assumptions of yield impact (i.e., moderate to heavy infestations over the entire C/H and aldrin use area in a given year - which is unlikely). The LP analysis was utilized to make comparisons of economic results during 1975-80 on a typical year basis (focus 1977 for convenience), on the assumption that the new policy had become fully effective, i.e., no C/H and aldrin available, and all other necessary economic adjustments had been made in the cropland sector to meet regional, national and export commodity demands. In terms of economic theory, a comparison was made in values of economic variables (e.g., price, acreage, production) under two differing conditions of equilibrium, without regard to transitional impacts of shifting from one equilibrium condition to another.

Some of the key impacts of the combined C/H and aldrin cancellation/suspensions at the national level were:

1.	Corn production	-36.9 million bushels (-0.7%)
2.	Acreage of corn raised with no pesticides	+5.55 million acres
3.	Acreage of corn raised with non-organochlorine insecticides	+1.4 million acres
4.	Corn acreage raised with organochlorines	-7.48 million acres
5.	Total corn acreage	+200,000 acres (0.4%)
6.	Total cropland in use	+1.16 million acres
7.	Price of corn and other grains	+1 to 3%
8.	Grain transport cost	+6.36 million (0.9%)
9.	Net returns to cropland (i.e., net farm income)	
	Corn	-$6.36 million
	Total (7 crops)	+$71.25 million (+2.2%)
10.	Consumer prices of meat products	+0.4 to 0.5%
11.	Consumer prices for all food	$364.8 million ($1.70/capita or 0.19%)

These impacts are well within the range of year-to-year variations due to the normal operation of the economy in response to economic factors, weather conditions, etc.

The estimates of impact can be reduced considerably if one does not assume a worst case estimate of yield impact. For example, the reduction in a most likely case basis could be in the range of one-half the above impacts. Also, if focus is strictly upon impacts attributable only to the C/H cancellation based on use patterns prior to the aldrin suspension, the impacts become quite nominal.

The magnitudes of difference between the two LP solutions are greater than one would expect in a given year because adjustments will be made over a period of several years. For example, shifts to alternatives already have been under way in 1974 and 1975 in line with the aldrin hearings and suspension. Also, these analyses hold cost and yield effects of substitutions for C/H and aldrin constant, which is not entirely realistic. It is reasonable to assume that there are trends toward development of pest resistance in C/H and in development of more effective substitutes over a 5 to 10 year time-frame, which could greatly reduce economic impacts of cancellation.

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Section IV

ECONOMIC AND SOCIAL IMPACTS OF CANCELLING CHLORDANE AND HEPTACHLOR ON OTHER AGRICULTURAL USES

This section contains a survey of other agricultural uses of C/H, for the purpose of identifying possible significant impacts. Focus is on citrus and several other agricultural uses on which C/H use and/or impact data are available. Limited and conflicting data place serious limitations on assessing impacts.

For C/H use on turf, in greenhouses, in nurseries, and for insect control in homes and other buildings, impacts are not evaluated. Amounts of C/H uses and the economic significance for these various categories are not quantified as data is unavailable for this type of analysis. However, recent surveys discussed below indicate that these uses are important and in some instances, such as use in nurseries, economically significant (7). For impacts needing further evaluation, interested parties should cooperate with EPA by providing data to assess these impacts.

From the point of view of crop production and other insect control problems, C/H poses certain desirable characteristics including lower costs, lower toxicity to users, and persistence which provides insect control over a longer period of time. As a result, a switch to alternatives of C/H will tend to increase cost of production. Available information indicates damaging insects on most crops can be controlled with alternative insecticides and the adjustment can be made relatively easily and inexpensively. For others, important economic impacts can result.

Citrus

The purpose of this section is to summarize economic and social implications of the cancellation of C/H and aldrin/dieldrin citrus. Earlier studies conducted by the Department of Agriculture on the impacts of cancelling chlordane and heptachlor are reviewed along with more recent studies by EPA. These studies indicate that cancellation of C/H and other organochlorine alternatives can have significant impacts on citrus production, although the quantities of C/H used on citrus are quite small.

Chlordane Impact Study by USDA

During 1966, 15,000 pounds of chlordane were used to treat approximately 8,300 acres of first and second year citrus plantings to protect them from termites (1). By 1971, the treatment was estimated to have declined to 4,500 pounds of chlordane applied to 3,000 acres of new plantings.

This USDA study assumed that there were no effective nonorganochlorine substitutes for control of termites on first and second year citrus plantings. This resulted in an estimated loss in value of production of $93,000 for the year (1971) based on the assumption that 5% of the 3,000 acres of first and second year plantings would have to be replaced at a cost of $147 per acre for a total of $22,050. The estimate also included production losses arising from the need to replace trees which require six years to reach fruit bearing age and an allowance for cost savings as a result of not using insecticides to control termites.

Using the same logic and assumptions inherent in the USDA study, the impact on citrus growers during 1974 would have been $107,000. Damage from uncontrolled termites would have required replanting of approximately .02 percent of Florida's 864,000 acres of citrus. The regional and national economic impacts associated with this loss would be minimal or nonexistent for both producers and consumers.

Heptachlor Impact Study by USDA

Limited amounts of heptachlor were used by citrus producers during 1966. According to the USDA study, less than 500 pounds were used for spot treatments to control soil insects and ants in the Southern Plains citrus producing area (2). No heptachlor was reported for citrus use during 1971 (3). Because of the limited use of heptachlor on citrus in recent years, no estimates were made by the USDA analysis of the economic impact of its cancellation.

EPA Analysis of C/H Cancellation on Citrus

Analysis of unpublished data underlying the USDA survey of pesticide use during 1971 shows California having the highest chlordane use on citrus. This data indicates that 17,800 pounds of chlordane were applied to 9,700 acres of citrus in the United States. California applied about 15,600 pounds to approximately 8,600 acres while Florida accounted for the remaining 2,300 pounds on an estimated 1,200 acres. Use in Florida was primarily for termite control while the California use was directed primarily at control of the Argentine ant which interferes with natural predators of scale insects. It has been further estimated that 25,400 pounds of chlordane was used on 8,112 acres (3.2 percent of California citrus acreage) during 1973.

A five percent granular chlordane compound applied either aerially or with ground equipment at a rate of 100 pounds per acre was the typical dose against Argentine ants during this period.

Substitute control programs use two to four ground applications of diazinon for one application of chlordane to directly control scale insects. One or two foliar applications of either parathion, malathion, carbaryl, guthion or supracide would be needed as an effective substitute for the chlordane treatment.

Since only a small proportion of the California citrus acreage (3.2 percent) requires treatment for control of Argentine ants and since the substitute control program has a small effect on citrus production costs, the direct regional and national impacts associated with a restriction in chlordane use for California's citrus industry are expected to be small. However, EPA is currently assessing these problems and results will be made available in the near future. The impact of cancelling this use would be felt primarily by the grower. Diazinon may not be a long run substitute as it is not presently supported by EPA registration. Such pesticides as parathion could upset pest management programs and require a reorganization of foliar spray schedules.

The impacts associated with cancellation of organochlorine insecticide use (including C/H) for citrus production were evaluated by EPA during 1973 in conjunction with the aldrin/dieldrin cancellation hearings. At that time, aldrin was the most widely used organochlorine insecticide and was applied through soil incorporation primarily to control root feeding beetles; use of aldrin for this purpose was limited to Florida. The expert opinion from Florida during the aldrin/dieldrin hearings was that chlordane/heptachlor would be used as an aldrin replacement in the event that citrus uses of aldrin were eventually cancelled.

It should be noted that registrations of C/H for root feeding beetles are not consistent between the state of Florida and EPA. The Florida Insect Control Guide (May 15, 1971) references aldrin, chlordane and dieldrin as recommended pesticides for control of Fuller's Rose Beetle and Citrus Root Weevil. However, there is no corresponding EPA registration for chlordane for Fuller's Rose Beetle. On the other hand, Stauffer Chemical Company does have an EPA registration for the use of heptachlor for control of these insects (EPA registration numbers 476-1801 and 476-1129), but heptachlor for this purpose does not appear in the Florida recommendations.

Since the problem associated with root feeding beetles is potentially severe for certain regions of Florida, the role of chlordane and heptachlor in the control of these insects will be analyzed even though this use does not appear in past insecticide use surveys, and the data relating to C/H efficacy is inconclusive.

The efficacy data relating to aldrin, dieldrin, chlordane and heptachlor is inconsistent. During 1958, King ran several experiments with these compounds. In one he found that heptachlor provided 96 percent control over Fuller's Rose Beetle while dieldrin and aldrin provided 92.5 percent and 78.2 percent respectively. In a second trial, aldrin performed the best by providing 78.9 percent control with dieldrin yielding 74.6 percent; heptachlor ranked third at 47.6 percent and chlordane performed poorly at 29.5 percent. In these tests no statement of statistical significance was associated with treatment means. King concluded from his work that severe root injury can be prevented by soil applications of 2.0 to 5.0 pounds of technical aldrin, dieldrin or heptachlor per acre (4).

More recently, Bullock has tested the performance of chlordane, dieldrin and a varied assortment of other compounds. In 1971, the use of dieldrin at a rate of five pounds a.i. per acre resulted in emergence of 3 beetles per trap while chlordane treatment of 5 pounds a.i. per acre resulted in a count of 9.4 per trap. In this test the control plot yielded 11.4 adults per trap. These mean reported counts were not significantly different from one another at a 5 percent significance level as evaluated by the new Duncan Multiple Range Test (5).

Minimal testing of these compounds has occurred in recent years. At the same time, C/H have not been used by growers for soil insect control. Therefore, the lack of reliable performance data from experimental work is compounded by a lack of use data under field conditions with the result that the substitutability of C/H for aldrin and dieldrin is most difficult to assess.

Although aldrin and dieldrin were used primarily to control the Fuller's Rose Beetle, they also provided varying control over an associated complex of soil insects including Citrus Root Weevil (*Pachynaeus litus*), Sugarcane Rootstock Borer Weevil (*Diaprepes abbreviata*), *Tanymechus* *lachena* and Citrus Leaf Notcher. Only minimal control over *Diaprepes* abbreviata has been afforded by aldrin, dieldrin, chlordane or heptachlor. This recently introduced pest has been subject to quarantine and eradication efforts in recent years with only limited success. According to Robert Brooks of the USDA Cooperative Extension Service, Lake Alfred, successful control for this insect has not yet been discovered.

Damage to the citrus tree is primarily by the larvae as they feed upon the roots, reducing both the root system and the canopy. This diminishes vitality and production, culminating in an uneconomical tree. While the damage is apparent, the causes are often ambiguous. Several pests can inhabit the groves and cause similar damage. Often the beetles' infestation can be substantiated only after the tree is removed from the soil. Persistent soil insecticides such as aldrin and dieldrin and perhaps C/H have proven convenient and efficacious because of their persistence (requiring only one soil application every three to five years) to control both termites and beetles. In addition, the soil application of chlorinated hydrocarbons has made it possible to introduce natural insect predators at considerable savings to growers. Part of these cost savings are the result of reduced spraying (by a factor of 3 to 7 applications) of other pesticides. Without an effective soil insecticide, the only option for beetle control is increased spraying of organophosphates to control adult beetles as they migrate from the soil to the foliage of trees. This option would probably not provide the same level of control as was maintained by aldrin. Soil insecticides provide maximum protection to citrus groves by interrupting the life cycle as the larvae migrate to the soil and by providing control over the number of adults who can move from the soil back to the foliage. Foliar sprays can be effective in reducing the adult beetle population at the time of application and shortly thereafter; however, because of the variability of the life cycle of the target insects, quarterly foliar applications would probably be required. In this event, the entire spray schedule would have to be restructured together with modifications in the current biological control programs.

Even if chlordane is available for beetle control, due to its lower performance, citrus specialists feel a modification of past spray schedules may be required. Rather than initiate an additional foliar spray, citrus entomologists would probably recommend that grove managers redesign their foliar schedule. One such option would be to change the summer scalicide spray of ethion and oil which is currently applied in mid-July to parathion and oil in mid-May or June. This option would still provide the scalicide protection as well as some control of adult beetles in the foliage to offset lower efficacy in the soil.

If left uncontrolled, the damage caused by Fuller's Rose Beetle could be severe with impacts distributed unevenly across the citrus growing regions of Florida. Citrus District Five, made up of Atlantic Coast counties including Brevard, Indian River, St. Lucie, Martin, Palm Beach, Broward, Dade, and portions of Volusia is characterized by groves planted on artificially constructed beds, surrounded by draining ditches, which were once partial swampland. High water tables limit the depth of the root systems; 90% of the roots are often concentrated in the top 18 inches of soil. In the central part of Florida, citrus roots can penetrate up to twenty feet and average twelve to sixteen feet.

In the coastal counties, a greater portion of the root system is available for larvae feeding. Thus, the same level of beetle infestation can result in greater damage for these trees than for inland groves. Discing in the inland groves to a depth of six inches around the trees may interrupt the pupation stage of the beetle thereby providing marginal, nonchemical control. In the coastal regions, discing to this depth would severely damage the root system. Without cultivation, grass and weeds compete with the tree for available moisture. For this reason, coastal groves are more susceptible to drought which in turn exerts a stress on the tree and leaves it more susceptible to damage by any factor that reduces the root system. The apparent paradox between high water tables and drought damage is explained by the fact that the root penetration is effectively limited by the average height of the water table. As the level declines during dry periods, the peripheral roots of coastal trees are unable to obtain sufficient moisture.

Without adequate control of root feeding beetles, citrus production in coastal counties could prove unprofitable for many groves. Using treatment history as a base to define infested acres (and assuming that treatment is made every three to five years), 25% of Florida's East Coast county citrus acreage could be subject to root damage. As a percentage of total Florida citrus, this coastal county acreage would affect approximately 6 percent of current citrus production (1972 base).

Because of an inelastic demand for citrus at the farm level, the market impact of a decrease in production would be an increase in farm level income to citrus growers in the aggregate. However, due to the greater potential for insect damage in the East Coast region, these growers could be subject to income reductions if an adequate control agent is not available.

Due to the uncertainty surrounding the efficacy and registration of C/H as soil insecticides for citrus and lack of information surrounding alternative controls for Fuller's Rose Beetle, it is difficult to predict social and economic consequences from C/H restriction. It can be stated that the suspension of aldrin and dieldrin negated the primary control of Fuller's Rose Beetle. Further, if no alternative control agent is discovered, the consequences could be severe for Florida's East Coast growers. Due to currently low income levels and a lack of alternative employment, a significant production decline would cause significant social impacts. The extent to which C/H can impact on this situation is unknown and, therefore, the economic and social implications of the C/H cancellation for citrus are difficult to assess with available information.

Other Crop Uses of C/H

Introduction

This section contains a survey of information on the extent of other C/H crop uses and possible impacts of cancellation. Surveys conducted by USDA provide an indication of the number of crops receiving treatment and the extent of treatment in terms of pounds and acres per year. This data is presented in Exhibits D (p.194) and F (p. 196) of Part II of this report. More recently, surveys have been conducted jointly by EPA and USDA. EPA conducted an informal telephone survey (1975 EPA survey) to several states requesting information on minor uses of C/H (6). In another survey, EPA requested USDA to distribute a questionaire to all states and possessions to inquire about recommendations of C/H for the 1975 growing season and to obtain estimates of total pounds of C/H used in their respective states and possessions (1975 USDA/EPA survey) (7). Table 20 summarizes the findings from this questionnaire (1975 USDA/EPA Survey). In addition, economic impact analyses for a variety of crops associated with cancelling C/H were conducted by USDA in 1972 and 1973 (1) (2). Using available information, economic impacts are briefly discussed for strawberries, potatoes, hay, tobacco, peanuts, apples, and vegetables as a group.

Table 20 -- Results of USDA/EPA cooperative survey of states on 1974 use and 1975 recommendations of C/H

State or Territory	Plan to recommend in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (and change from 1973)	
	Chlordane	Heptachlor	Chlordane	Heptachlor
Alabama	X	X	1,000,000	250,000
Alaska	X		50	
Arizona	X	X	150,000 (down from 1973)	4,000
Arkansas	X	X	no estimate	no estimates
California	X		estimate not given	estimate not given
Colorado	X	X	40 (down from 1973)	120 (down from 1973)
Connecticut	X		no estimate	no estimate
Delaware	X		no estimate	no estimate
Florida	X	X	1,124,193 (1973 estimate - sold)	260,367 (1973 estimate - sold)
Georgia	X		no estimate	no estimate
Guam	X		no estimate	no estimate
Hawaii			126,000 (1973)	no estimate
Idaho	X	X	313,000 (up for 1973)	no estimate
Illinois	X		715,708 (down for 1973)	270,645 (down for 1973)
Indiana	X	X	300,000 (plus termite and small package use)	300,000 (plus termite and small package use)
Iowa	X	X	75,100 (up from 1973)	500,000

Table 20 -- Results of USDA/EPA cooperative survey of states on 1974 use and 1975 recommendations of C/H (Cont'd)

State or Territory	Plan to recommend in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (and change from 1973)	
	Chlordane	Heptachlor	Chlordane	Heptachlor
Kansas	X	X	estimate not given	estimate not given
Kentucky	X		1,000 (down from 1973)	no estimate
Louisana	X		no estimate	no estimate
Maine	X		slightly more than 2,700 (up from 1973)	low - no estimate
Maryland	X		770,000 (70% for termites) (down from 1973)	61,000 (down from 1973)
Michigan	X		no estimate	231.3 (1973 use)
Minnesota	X	X	160,000 (1973 use) (does not include PCO, homeowner, or turf)	20,000
Mississippi	X	X	448,520 (up from 1973)	258,960 (up from 1973)
Missouri	X	X	no estimate	no estimate
Nebraska	X	X	100,000	25,000
Nevada	X	X	8,758 gal (1973)	1,601 gal (1973)
New Hampshire	X		no estimate	none
New Mexico	X	X	5,000	500
New York	X (ant only)		restricted use - ant use requested from N.Y. Dept. of Environmental Conservation	used by N.Y State Dept. Agr. to control alfalfa snout beetle. Amount use requested

Table 20 -- Results of USDA/EPA cooperative survey of states on 1974 use and 1975 recommendations of C/H (Cont'd.)

State or Territory	Plan to recommend in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (and change from 1973)	
	Chlordane	Heptachlor	Chlordane	Heptachlor
N. Carolina	X		1,750,000 (up from 1973) (1,000,000 lb of this total used on termites)	75,000 (down from 1973)
N. Dakota	X	X	79,600 (up from 1973)	1,900 (down from 1973)
Ohio	X	X	no estimate	no estimate
Oklahoma	X	X	no estimate	no estimate
Oregon	X		no estimate	no estimate
Pennsylvania			no estimate	no estimate
Puerto Rico	X	X	no estimate	no estimate
S. Carolina	X		no estimate	no estimate
S. Dakota	X	X	no estimate	no estimate
Tennessee	X	X	no estimate	no estimate
Utah	X		5,000	1,000
Vermont	X	use by permit only - no permits issued in 1973 or 1974	1,600 licensed applicators only - does not include formulation under 10% sold by outlets with no records of sale (up from 1973)	0
Virginia	X		no estimate	48 (1973 use)

Table 20 -- Results of USDA/EPA cooperative survey of states on 1974 use and 1975 recommendations of C/H (Concluded)

State or Territory	Plan to recommend in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (and change from 1973)	
	Chlordane	Heptachlor	Chlordane	Heptachlor
Washington	X	X	340,700 (lb sold - up more than tenfold from 1973 lb sold).	no estimate
W. Virginia	X		no estimate	no estimate
Wisconsin	X	X	no estimate	no estimate
Wyoming	X		no estimate	no estimate

Source: USDA/EPA survey (1974). See reference 7.

Strawberries

Results of two surveys, 1975 EPA Survey and 1975 USDA/EPA Survey, indicate possible adverse impacts on strawberry producers (6,7). Nineteen states recommend chlordane for soil insect control on strawberries; one recommends heptachlor. The strawberry plant is attacked by the root weevil and related weevils, and a variety of other soil pests, including wireworms, cutworms, and white grubs.

In the absence of chlordane, strawberry damage could be significant in some areas. For example, in Missouri where wireworms, white grubs, and carrot beetles are abundant soil pests, losing chlordane might result in losing viable plants 1 to 2 years before they would normally be discarded and in 5 to 10% more damaged berries in each crop. Such widely dispersed states as Oregon, Kentucky, Vermont and Ohio are concerned about unavailability of chlordane and the related cost, effectiveness, and lack of substitutes.

Several states believe that adequate but unregistered substitutes exist. For example, in the state of Washington, C/H has not been consistently effective, but Furadan, an effective substitute, is not registered. In New York, where the strawberry root weevil and the strawberry rootworm are pests, chlordane is the preferred treatment. Dianinon at 4 to 8 lb/acre and carbaryl at 8 lb/acre are almost as effective but are not registered at these dosages.

New York officials were not aware of an adequate substitute pesticide to control root weevils, although malathion and parathion are currently registered for adult root weevil control. Also registered are: carbaryl, methoxychlor, ethion, rotenone and endosulfan. It has been estimated that approximately 50% of the New York strawberry crop is susceptible to the root weevil or other insect infestations (8). A 3.3% strawberry loss related to wireworms resulted from substitution of diazinon for chlordane(8); 33 to 50% yield reduction could be attributed to white grubs if chlordane is cancelled and no substitutes are used (9). Brann also estimated a substantial strawberry loss in susceptible areas if effective alternatives for chlordane are not used (10).

Despite extensive damage to the New York crop, strawberry losses at the national level should be very small. In 1971 USDA estimated that 1,000 strawberry acres were treated with chlordane. After cancellation, the national yield would decline by an estimated 3.3% with an associated $75,000 impact.

Since California production has been expanding in recent years, national strawberry supply impacts from long term Pacific Northwest production changes should be minimal. There may be short term adjustment problems as local growers switch to other crops or attempt to grow fewer protected strawberries.

Most of the other states expecting impacts have 200 - 500 acres each of strawberries grown for fresh market consumption. The USDA study may be an understatement of impacted acreage, but it is difficult to assess the net monetary impact of the suspension. The short term impact may be considerably higher than $75,000 cited by the USDA study.

Potatoes

The 1975 EPA Survey indicates many states use chlordane on potatoes (6). Wireworms are the primary insects controlled by chlordane, but it is also used on white grubs, cutworms, and tuber flea beetles. Diazinon and parathion are the most frequently recommended alternatives, while Dyfonate and Phorate appear on several recommendations. The University of Idaho in 1971 reported that chlordane gives ten years effective control. Dyfonate and phorate were reported as providing good or better control, than chlordane, of sugar beet wireworms in potatoes but at a higher cost to the grower. It was indicated that Dyfonate and phorate were more acutely toxic to the user than chlordane. Extension entomologists in Colorado believe the impact of cancelling chlordane would be minimal on tuber flea beetle control in that state. Kentucky and Maine indicated that wireworms were only a problem in potatoes following a sod crop. Other states list user hazard, increased cost, more frequent applications, and decreased efficacy from the use of alternatives.

The USDA study on potatoes indicated that the impacts are expected to be small as other pesticides can effectively control insects in most instances (1).

Hay and Alfalfa

Hay, one of the major animal feeds produced in the U.S., is grown on more than 30 million acres of land. The lack of major insect pests precludes the need for insecticides on most hay crops. Tables 3 and 5 above show that 3,000 acres of hay were treated with chlordane and 2,000 acres were treated with heptachlor. An estimated 3,000 pounds of heptachlor were used on alfalfa. The results of the two most recent surveys do not provide any indication of adverse impacts from cancellation (6,7).

Tobacco

Tobacco production is one of the largest uses of insecticides on a per acre basis. However, most tobacco is not grown on a continuous basis on any given location and is usually a small proportion of a farmer's total crop area. As a result, insecticides which may leave residues in neighboring crops through drift or on subsequent crops, via persistence in the soil, are generally not recommended (11). In general, the less persistent organophosphate and carbamate insecticides are used more frequently than organochlorines (12). In 1971, the major foliar tobacco insecticides were endosulfan, toxaphene, TDE (DDD), disulfotan, parathion, malathion, azinphosmethyl (guthion), and methomyl. Carbaryl and diazinon were used in large quantities as soil insecticides.

Three thousand acres of tobacco were treated with heptachlor(2) and 17,000 with chlordane in 1971. Tobacco producers would have incurred an additional cost of $21,300 for alternative insecticides, $8,700 for 3,000 acres of field treatment and $12,600 for seedbed treatment due to cancellation of heptachlor. Unavailability of chlordane would increase producer's costs for alternative pesticides by about $14,000 (1). Yields of tobacco are unaffected by cancellation, if alternatives are used.

Peanuts

Although chlordane is not recommended for peanuts because of residue problems (10, 11), a minute quantity (100 lb) was used in 1971 (13). Cancellation for this use should have no impact.

Apples

A recent(14) survey was conducted to determine impacts of cancellation of C/H along with aldrin and dieldrin. The leading apple producing states in the nation, Washington, New York, Michigan, California, Pennsylvania and North Carolina, do not recommend chlordane or heptachlor for apple production. These six states produced 70% of the U.S. apple crop in 1974. Of these four pesticides, dieldrin has been the most important pesticide in apple production in the past, and it is not known to what extent C/H will be a substitute for dieldrin since its suspension. Many registered pesticides excluding C/H are available and effective; however, costs will increase as material costs of these alternatives rise. In Table 3, Part II, it is reported that 373,000 pounds of chlordane were applied on 10,000 acres of apples in 1971. The authors of this study investigated these estimates and were unable to substantiate these figures (14). In fact, they were unable to establish any significant use of chlordane on apples.

This study concludes that apple production does not depend in any important manner on C/H and cancellation in this use should have negligible effects (14).

Vegetables

Chlordane and heptachlor are effective soil treatments for wireworm and white grubs when pasture is converted to vegetable production. The USDA chlordane impact study(1) projected a 3% yield decline for a large group of miscellaneous vegetables. Approximately 5,000 acres are affected at a loss of $115,000.

Soybeans

Only 400 pounds of chlordane were estimated to be used on 8,000 acres of soybeans in the Appalachian region in 1971 (13). Many entomologists do not recommend chlordane use in soybeans because of residues. Since the treatments represent a minute percentage of both soybean acres and total insecticide use (0.86% of acreage and 0.043% of poundage in the region), economic impact is negligible.

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Section V

OTHER AREAS OF IMPACT AND CONCERN

This concluding part of the report covers a range of remaining issues related to the proposed cancellation. An important consideration at this time is demand on energy resources. Presented here is an evaluation of energy impacts due to differences in energy requirements between C/H and selected alternatives. Consumer price impacts are considered. An estimate is made of the percent increase in food prices and an evaluation is made of changes in demand for farm labor that may result from the cancellation. The most significant changes in crops grown and land use occur in the North Central regions; the decline in demand for labor appears to be relatively more important in this area. Energy, inflation and employment are the major macro-economic issues. Also discussed are the impact to the producer of C/H, the Nation's productive capacity for registered substitutes for certain pest-crop combinations, use of scouting for crop pests, and safety in the use of pesticides. The concluding statement concerns termite control, a use not covered by the cancellation order.

Relative Energy Intensity of C/H and Representative Substitutes

Energy consumed to produce 1 million pounds of C/H and three representative substitutes was estimated. To provide net energy requirements, C/H are compared with these substitutes at assumed rates of application for equivalent pest control.

Carbofuran is a major substitute and is representative of the carbamate class of pesticides. Diazinon, representing the organophosphates, is an important substitute and is analyzed because of its chemical complexity. Carbaryl, a widely used carbamate, is included in the analysis.

Tables 21 and 22 show the amounts of electricity, coal and petroleum used to produce one million pounds of each pesticide. The three bottom rows of each table show the amount of energy consumed per category at equivalent rates of application, for all three substitutes considered as a group (row 9), and the net effect compared with chlordane and heptachlor (row 10). Chlordane tends to be more energy intensive than the substitutes chosen for comparison while heptachlor consumes less energy.

Table 21--Comparative energy impact per million pounds chlordane replaced[1]

Insecticide	lb/lb of chlor. replaced	Million kWh of elec.temperature(T)	Coal for process heat, T	Petroleum for feed + inerts, barrels (bbl)	Total petroleum, for feed + inerts + elec., bbl	Total coal, for process heat + elec., T
Assuming pound-for-pound replacement:						
1. Chlordane	1	4.21	160	1,090	9,330	2,030
2. Diazinon	1	5.2	480	3,600 (feed alone, 2,040)	13,760 (ex inerts, 12,200)	2,790
3. Carbofuran	1	6.26	640	850	13,130	3,420
4. Carbaryl	1	3.3	320	-0-	6,460	1,780
Replacement at assumed application rates:						
5. Chlordane	1	4.21	160	1,090	9,330	2,030
6. Diazinon	0.65	3.38	312	2,340 (feed alone, 1,325)	8,960 (ex inerts, 7,945)	1,812
7. Carbofuran	0.25	1.57	160	213	3,285	855
8. Carbaryl	0.5	1.65	160	-0-	3,230	850
9. Total substitutes [2]		2.42	232	1,190	5,925	1,307
10. Net impact per million pounds of chlordane [3]		-1.79	+72	+100	-3,405	-723
11. Net impact for 1974 [4]		-28.64	+1,152	+1,600	-54,480	-11,568

[1] Source: Chemistry Branch: C&L Division, OPP, EPA

[2] Calculated assuming substitutes will replace chlordane in the ratio diazinon: carbofuran: carbaryl = 7:7:1, expressed in units of (chlordane-equivalents + 15). This ratio is a composite of projections done for EPA, taking diazinon as a representative of all organophosphate substitutes.

[3] Total substitutes less chlordane.

[4] Using an assumed domestic consumption rate of 16,000,000 pounds of chlordane for 1974.

Table 22--Comparative energy impact per million pounds heptachlor replaced[1]

Insecticide	10^6 lb of hept. replaced	Million kWh of elec.	Coal for process heat, T	Petroleum for feed + inerts, bbl	Total petroleum, for feed + inerts + elec., bbl	Total coal, for process heat + elec. T
Assuming pound-for-pound replacement:						
1. Heptachlor	1	3.9	225	1,200	8,850	1,955
2. Diazinon	1	5.2	480	3,600 (feed alone, 2,040)	13,760 (ex inerts, 12,200)	2,790
3. Carbofuran	1	6.26	640	850	13,130	3,420
4. Carbaryl	1	3.3	320	-0-	6,460	1,780
Replacement at assumed application rates:						
5. Heptachlor	1	3.9	225	1,200	8,850	1,955
6. Diazinon	1.3	6.74	624	4,680 (feed alone, 2,650)	17,920 (ex inerts, 15,890)	3,624
7. Carbofuran	0.5	3.14	320	425	6,570	1,710
8. Carbaryl	1.0	3.3	320	-0-	6,460	1,780
9. All substitutes 2/		4.83	464	2,380	11,850	2,615
10. Net impact per million pounds of heptachlor 3/		+.93	+239	+1,180	+3,000	+660
11. Net impact for 1974 4/		+3.72	+956	+4,720	+12,000	+2,640

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1. Source: Chemistry Branch, C&E Division, OPP, EPA

2. Calculated assuming substitutes will replace heptachlor in the ratio diazinon: carbofuran:carbaryl = 7:7:1, expressed in units of ((lb. of insecticide equivalent in insecticidal action to 1 lb. heptachlor) - 15). The 7:7:1 ratio is a composite of projections done for EPA, taking diazinon as representative of all organophosphate substitutes for heptachlor.

3. Index for total substitutes less that for heptachlor.

4. Using an assumed domestic consumption rate of 4,000,000 pounds for 1974.

Total domestic consumption of chlordane exceeded that of heptachlor in 1974 by an estimated four times. The bottom row in each table shows net energy usage assuming 16 million pounds of chlordane and 4 million pounds of heptachlor. These energy impacts which are annual estimates are exceedingly small as the U.S. consumes approximately 13 million barrels of crude oil each day.

Appendix D provides a list of assumptions used to derive energy estimates. Other energy implications of the cancellation have not been evaluated, such as impacts on energy use due to changes in crop acreage.

Inflationary Impact of Cancellation

The linear programming model provided quantitative estimates of changes in the value of feed and food crops associated with C/H cancellation. The total change in the cost of meeting final demand for food at the farm level was $364.8 million.

To estimate consumer level impacts, all food considered as a group was analyzed as a parallel upward shift in the supply cost of these grains in the face of an inelastic demand at the retail level. This type of change implies that all of the increase in price is passed on to the consumer. It also implies that all adjustments in expenditures for food take place in the prices of commodities, since the quantity of food available remains the same on a per capita basis. The $364.8 million impact can be used to estimate the change in food price at retail by determining the cost as a percent of expected expenditures for food in 1977. The increase in the price level of all food to consumers was estimated to be 0.191%. For those meat products depending heavily on grain, price increases would be somewhat higher and range from 0.4% to 0.5%.

Impacts of cancelling other C/H uses are not expected, individually, to have a significant impact on the consumer price level. Generally these other uses involve products or services which are small potions of consumer expenditures. There could be notable consumer cost impacts in isolated instances where alternatives are not highly efficacious or are much more expensive. This, however, would not be the general rule, based on available information.

Labor Displacement in the North Central Region

The assessment of the proposed cancellation, accomplished through the use of EPA's linear programming model, indicates that the greatest shifts in production and pesticide use will revolve around an anticipated reduction in corn production in the seven states of the North Central region. Therefore, this region has been selected for closer analysis of potential post regulatory agricultural adjustment problems.

The linear programming equilibrium solution for a proposed C/H cancellation for food crop uses suggests several problems for the North Central consuming region, consisting of Ohio, Michigan, Indiana, Illinois, Missouri, Iowa, and Wisconsin. The model indicates most other regions in the nation will realize gains in the agricultural sector, both in terms of land devoted to production and in net income, largely as a result of land in the North Central going out of corn production and land in other regions coming into corn production. Specifically, a net of 1,490,000 acres will shift from corn to other uses, yielding some lower economic returns in the North Central region. Another reallocation effect will be the placement of between 290,000 - 354,000 acres in an idle use status. It is likely, of course, that before too much times passes some portion of the idle land would be put to other uses. Some of the uses may be agricultural, e.g., pasture land; however, land located in urban fringe areas could be converted to nonagricultural uses.

Production reallocation has two important effects. First, reduced corn production will force livestock owners to import more corn from other regions and at the same time substitute other indigenous grains for feed. This could make meat and milk more expensive. It definitely means that more energy resources will be required to transport feed into the areas to the extent that present feeding practices continue. The other important effect is reduced farm labor.

Of the seven commodities considered by the LP (linear programming) model, six are produced on a significant scale, cotton being a minor crop in the region. Among these commodities corn is the most labor intensive. Since corn production will be reduced, agricultural labor will also be reduced. In addition, the 290,000 - 354,000 acres of idle cropland will result in a further decreased labor demand. This acreage represents only about .5% of land presently growing the seven commodities of the LP model. Nevertheless, this drop does entail a measurable reduction in labor.

In Table 23 low and high estimates of reduced labor through shifts to less labor intensive land uses (including idle land) are computed.

Table 23. Labor displacement estimates for the north central region due to C/H cancellation, 1977

	(1) Before Cancel-lation Acres	(2) After Cancel-lation Shifts	(3) Man-Hours Required: High Estimates	(4) Man-hours Required: Low Estimates	(5) Total Labor Hours Required High Estimate	(6) Total Labor Hours Required Low Estimate	(7) Hourly Wages:* High Estimate
1. Barley Dryland	350,000	+160,000	2.80**	2.06**	448,000	329,600	$1.64**
2. Corn Dryland	760,000	+ 80,000	5.90	4.82	472,000	385,600	1.64
3. Cotton Dryland	0	0	10.50	-	-	-	1.38
4. Soybean Dryland	30,440,000	+1,040,000	4.85	3.44	5,044,000	3,577,600	1.64
5. Oats Dryland	720,000	-10,000	2.80	2.06	-28,000	-20,600	1.64
6. Sorghum Dryland	820,000	+90,000	4.74	3.86	426,600	347,400	1.58
7. Wheat Dryland	3,490,000	-70,000	3.24	2.57	-226,800	-179,900	1.64
8. Corn Dryland (no pesticides)	15,340,000	+4,260,000	5.90	4.82	25,134,000	20,533,200	1.64
9. Corn Dryland (other pesticides)	6,830,000	+1,200,000	5.90	4.82	7,080,000	5,784,000	1.64
10. Corn Dryland: C/H pesticides	7,030,000	-7,030,000	5.90	4.82	41,477,000	33,884,600	1.64
slack alds	2,320,000	-					
11. Land Use Totals	74,140,000	-280,000 (idle acres)	-	-	-3,127,200	-3,127,700	
12. Equivalent no. of man-days based on 10-hour work day					-312,720	-312,770	
13. Equivalent of workers utilized based on 25-day seasonal level of effort					12,508	12,511	
14. Dislocation of hired workers (assuming hired labor comprises 75 percent of the work force)					9,382	9,383	

	(8) Hourly Wages:* Low Estimate	(9) Total Labor Costs High Estimate	(10) Total Labor Costs Low Estimate	(11) Mean Income Loss: High Estimate	(12) Mean Income Loss: Low Estimate
1. Barley Dryland	$1.31**	$ 734,720	$ 431,776		
2. Corn Dryland	1.31	774,080	505,136		
3. Cotton Dryland	-	-	-		
4. Soybean Dryland	1.31	8,272,160	4,686,656		
5. Oats Dryland	1.31	45,920	26,986		
6. Sorghum Dryland	1.38	674,028	479,412		
7. Wheat Dryland	1.31	371,952	235,669		
8. Corn Dryland (no pesticides)	1.31	41,219760	26,898,492		
9. Corn Dryland (other pesticides)	1.31	11,611,200	7,577,040		
10. Corn Dryland C/H pesticides	1.31	68,022,280	44,388,826		
Slack land					
11. Land Use Totals		5,154,204	4,037,755		
12. Equivalent no. of man-days based on 10-hour work day					
13. Equivalent of workers utilized based on 25-day seasonal level of effort					
14. Dislocation of hired workers (assuming hired labor comprises 75 percent of the work force)		$3,865,653	3.028,16	$412	$323

*Labor costs are based on 1970 dollars

**Figures were not available for barley; wage rates for oats were substituted.

Source: Worden, G. et. al., Selected U.S. Crop Budgets, Yields, Inputs, and Variable Costs -- North Central Region. U.S. Department of Agricultural, Economic Research Bulletin No. 458, Vol. II, Washington, D.C. 1971.

EPA linear programming analysis, 1975.

using USDA budget estimates of man-hour requirements for the various commodities. This data is not in a form that easily lends itself to the task of associating soil type as well as land use categories to man-hour requirements. Therefore, budget data was searched for high and low figures for each commodity produced among all of the states in the region. The application of this data provides estimates of total reduction in man-hours (columns 5 and 6). It is derived by multiplying post-cancellation shifts in land use figures (column 2) by per acre labor requirements (columns 3 and 4). In row 12, the equivalent of man-days has been computed by dividing total man-hours by an assumed 10-hour work day. Next, in row 13, an equivalent of agricultural workers is computed by dividing man-day equivalents by an assumed average number of work days (25) required during the growing season for the commodities in question. Finally, in row 14, the figures are adjusted for owner and managerial classes of labor (25% of the labor force). The adjusted figures represent the hired pool and, thus, the hired farm workers estimated to be subject to income losses.

High and low budget figures for hourly wages are then identified in the same manner that man-hour figures were selected (columns 7-8). In columns 9 and 10, these figures are adjusted to focus on that portion of the work force that consists of hired workers. In the final column of the table, average losses per worker are computed by dividing estimates of the number of workers into the total income loss estimated for this group. The overall results for the region indicated by this analysis are that approximately 9400 workers are subject to average income losses ranging between $323 and $412 annually.* If these losses are distributed evenly over all income classes of workers and uniformly distributed geographically, it would be a matter of little concern. This is especially true where the production adjustments which create income losses occur gradually, as expected here.

Unfortunately, the anticipated losses may be concentrated in relatively small areas of the states. This could be a serious problem if unemployment remains at high levels through 1977; the North Central region has been hard hit by industrial unemployment. The chances for hired workers to supplement farm income are uncertain.

It should be emphasized that the available data did not permit full consideration of the distributive effects of farm labor income losses, e.g., groups and sub-regions most affected. However, one can surmise that: (a) where crop shifts are necessitated by increasing production costs, the older farmers and those with small capital resources will have the greatest difficulty in readjusting their land to profitable uses, and (b) a portion of the families of some farmers and the families of a still larger number of farm workers may find themselves temporarily adjusting to lower incomes.

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*These estimates may actually prove to be conservative since agricultural budget census data has a tendency to under-represent seasonal labor.

Impact of Proposed C/H Cancellation Order on the Producing Firm

Velsicol Chemical Corporation, the sole producer of C/H, is a subsidiary of Northwest Industries, Inc. The Chemical Group of Borthwest Industries, Inc. which includes Velsicol Chemical Corporation and Michigan Chemical Corporation had net sales of $167 million in 1974 (1). The proposed cancellation of C/H for agricultural and home and garden uses is cited in 1974 Annual Report of this firm along with an estimated sales for these uses of approximately $14 million, or 8.4% of net sales for 1974.

The proposed EPA cancellation would affect 31% of chlordane production and 66% of heptachlor production, based upon 1974 use breakdowns. Using prices for technical material at the plant in the March 31, 1975 issue of "Chemical Marketing Reporter" -- $.69/lb for chlordane and $1.25/lb for heptachlor -- these quantities are valued at $6,7000,000 or roughly one-half the sales figure loss stated by the company. EPA is unable to explain the differences in the loss estimates at this time; however, requests have been made to Velsicol to provide additional information needed to make more accurate determination of dollar loss. The real loss to Velsicol is the discounted value of net returns from prohected sales of cancelled uses several years into the future. Other data have been requested from Velsicol to more adequately evaluate impacts on employment, local communities where plants are located, and formulators.

The cancellation opens a market to new pesticides to the extent that replacements are needed. Environmentally acceptable substitute pesticides are likely to enhoy a premium price in the market.

Supply of Substitutes for Chlordane and Heptachlor

The 1971 production estimates for various insectiicdes, including many substitutes for C/H, can be found in Table 24. The data is not indicative of present full capacity production, since the information does not reflect changes in physical plant capacity or the effects of feedstock shortages.

More recent estimates on the availability of registered substitutes were found in reviews of the Substitute Chemical Programs and in a contract report by Theodore Riedeburg Associates (2) (Table 25). However, the more current information represents a very small proportion of the registered substitutes for C/H.

From the provided data, limits on supply expansion were found in 1973 and 1974 because of feedstock shortages. The feedstock shortage was also accentuated by the escalated demand for pesticides to treat increased acreage (3). In a few situations, the feedstock shortage was a deterrent to managerial decisions to invest in additional production facilities.

The supply of C/H substitutes will become less restricted as intermediates become more available. Also, if the demand for organophosphates expands, pesticide manufacturers will have an economic incentive to manufacture feedstocks or possibly alter nonsubstitute organophosphate production lines to produce C/H substitutes. These changes would not be instantaneous since lead time is necessary to alter raw material orders, production schedules, and product distribution systems (4).

In addition, there are opportunities to expand the domestic supply in the short run by reducing exports or increasing imports.

If C/H are cancelled in 1976 or 1977, and if inventories of C/H can be used, it is likely that the insecticide industry will have enough capacity to produce an adequate supply of subsittutes. Within one or two years, it is possible to increase plant capacities to produce substitutes or to develop additional supplies of feed stocks to adequately expand the supply of final products.

A potential problem, however, is the absence of registered alternatives for specific uses. This question has been explored earlier for agricultural uses; but gaps in domestic, commerical and public health uses were not explored. Sixty-eight percent of the marketed chlordane and 50% of the heptachlor is used for these purposes (EPA Estimate, 1974).

Table 25 -- Supply characteristics of registered substitutes for chlordane and heptachlor

Type of Insecticide	Estimated Production	Est. Domestic Full capacity Production	Estimated Imports	Estimated Exports	Comment
	pounds				
Methyl parathion (1)	51 million (1972)	perhaps as high as 100 million	1.1 million (1972)	12.5 million (1972)	Some of the methyl parathion production capacity can be used to manufacture other organophosphates.
Azodrin (2)	9-11 million (1973)	14 million	none	4.5-6.0 million (1973)	Production capacity may expand 25 to 30 percent if the feedstock shortage problem is solved. Additional supply possibilities from foreign producers conceivable.
Dursban (3)	5-7 million (1973-1974)	NA	not substantial	not substantial	Production is well below full capacity because of the shortage of the feedstock DEPCT. COnstruction of a DEPCT plant is underway. A dursban production plant is planned for completion in 1976 in Europe to help meet U.S. demand.
Diazinon (4)	6-7 million (1974)	6-7 million (1974)	negligible	1.0-1.5 million (1974)	Production capacity may expand if the feedstock shortage problem is solved. Two foreign producers are known to exist.
Dimethoate (5)	2 million (1972)	NA	not substantial	not substantial	Existing plant capacity can be used to manufacture other organophosphates.
Guthion (6)	4 million	NA	negligible	NA	Production capacity limited. Only by the availability of feedstocks. One foreign producer is known to exist.
Aldicarb (7)	1.0-1.5 million (1972)	NA	none	400,000-700,000 (1972)	
Malathion (8)	24 million (1972)	NA	153,800 (1972)	8 million (1972)	
Demeton (9)	none	none	173,000 (1971)	none	
Phorate (Thimet) (10)	8 million (1971)	28 million (1969)	none	NA	Existing plant capacity can be used to manufacture other organophosphates. Feedstock shortages will probably constrain supply in 1975.
Furadan (11)					Tight supply expected in 1975 with easing expected in 1976
Dyfonate (11)					Adequate supplied available in 1975 and it may be possible to fill some of the shortages in phorate and furadan.

Table 25. (Continued)

Carbaryl (11)	Tight supplies expected, but capacity should increase by 60 percent at the end of 1976. Supply constraints may exist because of feedstock shortages.
Counter (11)	High volume of production for this new registration cannot be expected until 1976-1977. Perhaps a million pounds can be produced in 1975 and possibly a multi-million pound plant will be available in 1978.

Sources:

(1) EPA,OPP, Initial Scientific and Mineconomic Review of: Methyl Parathion, October 1974.

(2) Arthur D. Little, Inc., Azodrin: Initial Scientific and Mini-Economic Review, draft, Cambridge, Massachusetts, October 1974.

(3) Arthur D. Little, Inc., Dursban: Initial Scientific and Mini-Economic Reviews, draft, Cambridge, Massachusetts, December 1974.

(4) Arthur D. Little, Inc., Initial Scientific and Mini-Economic Review of Diazinon, draft Cambridge, Massachusetts, February 1975.

(5) Arthur D. Little, Inc., Initial Scientific and Mini-Economic Review of Dimethoate, draft Cambridge, Massachusetts, January 1975.

(6) Arthur D. Little, Inc., Guthion Initial Scientific and Mini-Economic Reviews, draft, Cambridge, Massachusetts, October '74.

(7) Midwest Research Institute, Initial Scientific and Mini-Economic Review No. 5: Aldicarb, draft, Kansas City, Missouri, August 1974.

(8) Midwest Research Institute, Initial Scientific and Mini-Economic Review of Malathion, draft Kansas City, Missouri, September 1974.

(9) EPA, OPP, Demeton Mini-Economic Review, draft, July 1974.

(10) EPA, OPP, Minieconomic Review Phorate, draft June 1974.

(11) Theordore Riedeburg Associates, Pesticide Use for Control of Soil Borne Insects in Corn in the States of Indiana, Illinois, Iowa, and Missouri.

An examination of the summary (Appendix E, Table 1) for domestic, commercial and public health uses of chlordane/heptachlor indicates that there are substitutes registered for most uses. Under "special uses," a category which includes public health and forestry plantations, for two of the five pests there apparently are no registered alternatives. The largest use category, "lawn and nursery soil applications," proved to be the category with the greatest number of pests for which substitutes are not registered. Of the 31 pests registered for chlordane/heptachlor use, 11 or 1/3 lack registered substitutes. However, in categories where substitutes are lacking some of the pests are minor, e.g., lawn earthworms. In other cases, an examination of current state extension service recommendations reveals that some states have registered substitutes for certain pests not covered by federal registrations. For example, Mississippi shows lindane, zectran, metaldehyde baits and malathion baits as substitutes for lawn/ornamental control of pillbugs, sow bugs, snails and slugs.

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Table 24 -- Estimated production of various insecticides: 1971

Organophosphate	Production (million pounds)	Type of Chlorinated Hydrocarbon	Production (million pounds)	Type of Carbamate	Production (million pounds)	Insecticides	Production (million pounds)
Methyl parathion	45	Toxaphene	50	Carbaryl	55	Carbophenothion	2
Malathion	30	Methoxychlor	10	Carbofuran	8	Dimethoate	2
Parathion	15	Dicofol	5	Bux	6	Crufomate	2
Diazinon	10	Endosulfan	2	Methomyl	2	Dichlorvos	<1
Disulfoton	8	Chlorobenzilate	2	Aldicarb	2	Omite	<1
Azodrin	5	Endrin	<1			Binapacryl	<1
Guthion	4	Lindane	<1			*Bacillus thuringiensis*	<1
Dasanit	4	Mirex	<1			Polyhedral virus	<1
Dyfonate	2	Chloropropylate	<1			Pyrethrins	<1
Ethion	2					Rotenone	<1
Ronnel	2					Nicotine	<1
Naled	2					Lead arsenate	6
Abate	<1					Calcium arsenate	2
Coumaphos	<1						
Fenthion	<1						
Dioxathion	<1						
Dichlofenthion	<1						
[illegible]	<1						
Oxydemetonmethyl	<1						
Mevinphos	<1						
Phosphamidon	<1						
Dicrotophos	<1						
Aspon	<1						
TEPP	<1						
Mocap	<1						

SOURCE: EPA, Office of Water Programs, Pollution Potential in Pesticide Manufacturing, June 1972.

Corn Scouting Programs

As noted earlier, cutworm infestation of corn is the major problem in the North Central region that would be affected by C/H cancellation. A major alternative control being considered by cornbelt states is a baiting/scouting program. This program begins with a survey of the pest populations in a corn field to determine the infestation level. The strategy is that chemicals should be applied as needed and not on a schedule. The essential requirement is that an economic damage threshold be established to determine when to apply the insecticide. Once the decision is made, baits or sprays are applied. Periodically, scouts return to inspect fields for insect activity and determine whether or not the damage level warrants further treatment.

Many farmers would be expected to do their scouting in connection with other routine operations or as a special activity at no added out-of-pocket cost. However, some farmers may need to have the work done on a custom basis. Costs of scouting on a custom basis are available from the 1973 and 1974 Indiana Corn Pest Management Program (5). data indicates the estimated cost to the farmer for scouting field corn (excluding treatments) was between $.50 to $1.34 per acre. It should be emphasized that not all infested areas will be scouted during each growing year. Thus, scouting costs vary according to the number of acres that must be sampled for accurate results.

The scouting costs reflect the farmer's expenditures for specialized services which are supplied by a single consulting organization for a single fee. These services include field data collection, data analysis, and professional recommendations for pesticide applications. While these services demonstrate an additional cost factor they need to be compared with the prevailing expenditures for insecticides in order to appraise cost differences properly. It should be noted that scouting has the potential to reduce the per farm expenses for pest control. Nevertheless, other issues need to be considered in order to establish the residual benefits of this type of pest control program.

For the scouting program to be effective on corn, it is essential that the scouts be provided with some basic knowledge of entomology. While graduate entomology students are currently being used as scouts in an experiment in Indiana and Missouri, it would seem that high school seniors with some training can be scouts. Due to their busy schedule not all farmers can do their own scouting. Since scouting is a seasonal activity, it might provide temporary employment.

There are some important questions concerning scouting techniques and baiting procedures which cannot be answered at this time due to the current state of the art. Certain management cost problems have to be resolved; states that have experimented with scouting have not addressed the question of availability of reliable labor supplies for scouting, nor have they addressed the related management problems of organizing these services. Will farmers independently conduct insect scouting programs or will private contractors or extension service agents perform this task? What adjustments in cultural practices for corn production must be made by a grower in order to coordinate scouting/baiting practices? Each of these questions involves management problems which may entail some changes in farm organization and/or added managerial costs not reflected in the above cost figures. Thus, although scouting/baiting strategies appear to be constructive approaches to cutworm control from an ecological standpoint, it is difficult at present to make final judgment on short term feasibility.

Substitute Insecticides and Safety Problems

The cancellation of heptachlor and chlordane pesticides on corn would require the use of substitutes primarily from the carbamate and organophosphate groups (see earlier discussion of substitutes). The acute toxicity of many organophosphates presents a health concern. The labels detail precautions to be taken, but if people are not familiar with their dangers, understanding the label may not be sufficient to avoid accidents. Moreover, the effects of organophosphates are not always immediate; a person can be exposed for a number of days before symptoms appear.

Application and field work carry the greatest risks of exposure to substitutes. Yet, all exposed groups, including field workers and others entering a field that has been baited, are subject to a relatively small risk because dermal or respiratory contact is likely to be limited in most use situations. Increased risk to children on the farm or in the home is possible with storage and use of more acutely toxic substitutes.

Termite Control

C/H for termite control in structures is expected to be in strong demand to prevent damage to buildings of all types. Chlordane is the most popular termite control agent and an estimated 68 percent of its domestic use is for this specific purpose. Cancellation of C/H would leave aldrin, dieldrin, BHC and lindane as the major registered termite pesticides.

Termite control is a major annual expenditure accounting for not less than $250 million annually (1/3 for repair to damaged structures and 2/3 for chemical control). Additional termite damage to utility poles, fence posts and other similar wood is estimated at $500 million annually (6). The value of protection of structures from C/H is not known. In the absence of this information, a reasonable estimate is that it is substantial. Alternatives to the chlorinated hydrocarbon class of pesticides lack the quality of persistence which is essential for inexpensive and effective control of termites. A cancellation of these pesticides could have severe and long lasting economic consequences until equally cost-effective pesticides become available.

A secondary cost associated with cancelling C/H (and other chlorinated hydrocarbons) would have adverse effects on the market for construction of new buildings such as private homes. A cancellation of these termite controls would leave exterminating firms without effective alternative controls and these firms may be unwilling to provide guarantees of termite protection to owners of new homes, a condition normally specified in conventional mortgages and required in VA and FHA mortgages. A slowdown in new construction would be detrimental to the national economy at this time since this market is countercyclical and has been credited with stimulating the economy as a whole in recessionary periods.

References for Section V

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(3) Straube, H. L., (Chairman, Ad Hoc Committee on Shortages, National Agricultural Chemical Association). Statement before the Subcommittee on Agricultural Credit and Rural Electrification, July 25, 1974.

(4) Williams, J. A. (Chairman of the Board, Helena Chemical Company). Testimony presented at the Consolidated Aldrin/Dieldrin Hearing.

(5) USDA, Indiana Corn Pest Management Program, Project Summary, Washington, D.C., 1974.

(6) USDA, "Subterranean Termites, Their Prevention and Control in Buildings," Home and Garden Bulletin No. 64, Washington, D.C., January 1972.

APPENDICES
TO
PART I

APPENDIX A

Table 1. EPA registered insecticides for corn insects other than rootworms, cutworms and wireworms.

Table 2. Results of field testing of an organochlorine (aldrin) to control cutworm in corn in Missouri.

Appendix A, Table 1.--Summary of EPA registered controls for pests, other than rootworms, cutworms and wireworms attacking corn, 1975

Corn Pest	Chlordane	Heptachlor	Aldrin	Carbaryl	Carbofuran	Methyl Parathion	Parathion	Thimet	Diazinon	Diazinon/ Lindane	CS_2
	Soil/foliar applications										
Asiatic garden beetle larvae	x	x	-	-	—	-	-	-	-	-	-
Billbugs	-	x	-	-	-	-	-	-	-	-	-
Cornfield ant	x	x	-	-	-	-	-	-	-	-	-
Corn root aphid	x	-	-	-	-	-	-	-	-	-	-
Grape colaspis	-	x	-	-	-	-	-	-	-	-	-
Green June beetle larvae	x	x	-	-	-	-	-	-	-	-	-
Japanese beetle larvae	x	x	x	-	-	-	-	-	-	-	-
Flea beetle larvae	x	x	-	-	-	-	-	-	-	-	-
False wireworm	x	x	-	x	x	x	-	-	-	-	-
Maize billbug	x	x	-	-	-	-	-	-	-	-	-
Masked chafer larvae	x	x	-	-	-	-	-	-	-	-	-
Sod webworms	x	x	-	-	-	-	-	-	-	-	-
Seedcorn beetle	x	x	x	-	-	-	-	x	-	-	-
Seedcorn maggot	x	x	x	-	-	-	-	-	x	x	-
Whitefringed beetle	x	x	-	-	-	-	-	-	-	-	-
White grubs	x	x	x	-	-	-	x	-	-	-	
Red harvester ant	-	-	-	-	-	-	-	-	-	-	x
	Seed treatment										
Insects attacking seed corn	x	x	x	-	-	-	-	-	-	x	-

SOURCE: Preliminary summary of registered chlordane and heptachlor uses and alternatives, Criteria and Evaluation Division, OPP, EPA, by Fred Hageman undated.

Appendix A, Table 2--Comparison of Yields and Standcounts in Areas Treated with Aldrin and in Untreated Areas Areas from Farmer Cooperator Fields, in Seven Different Montana Counties, 1972

Code No.	Cooperator's Name	County	Treatment a.i./acre	Bushel Yield in Treated Area a/	Bushel Yield-Check Area a/	Standcount-Treated Area	Standcount In Check Area
P-1	Ronald Adam	Clinton	Al. 1 3/5	120.00	123.00	16,000	16,000
P-2	Reo P. Elliot	Clinton	Al. 1 3/4	134.00	124.00	18,500	16,500
P-3	John E. Gall	Clinton	Al. 1 1/2	128.00	120.00	16,000	16,000
P-4	Bill B. Hughes	Clinton	Al. 1.0	147.00	114.00	15,000	13,000
P-5	Bob Siela	Buchanan	Dasanit 3/4	107.00	106.00	16,000	16,000
R-2	William Graham	Ray	Al. 1 1/2	119.00	77.00	18,500	16,000
R-3	Billy Joe Schell	Platte	Al. 2.0	125.00	124.00	18,000	17,000
R-4	C. E. Crabtree	Clay	Al. 1.0	140.00	134.00	19,500	19,500
M-1	Ralph Little	Saline	Al. 2+Bux 1	63.00	71.00	12,000	12,500
M-2	Ron Linneman (fd. 1)	Carroll	Al. 1.0	115.00	120.00	19,500	19,000
M-2a	Ron Linneman (fd. 2)	Carroll	Al. 1.0	126.00	125.00	20,500	21,500
M-3	Holton Eschenbach (1)	Carroll	Al. 1.0	109.00	96.00	17,500	16,250
M-3a	Holton Eschenbach (2)	Carroll	Al. 1.0	132.00	132.00	21,000	21,000
			TOTAL:	1,569.00	1,466.00	228,000	228,250
			AVERAGE:	120.69	112.76	17,538	16,942
R-1	Royce Carter	Ray	Al. 1/5+ Modcap 1	89.00		17,500	
R-1	Royce Carter	Ray	Al. 1 1/5 only	90.00		18,000	

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a/ Estimated yield calculated using a Corn Yield Calculator developed by the Cooperative Extension Service, University of Illinois.

APPENDIX B

SUBSTITUTES FOR ALDRIN, DIELDRIN, CHLORDANE AND HEPTACHLOR FOR INSECT CONTROL ON CORN AND APPLES

SUBSTITUTES FOR ALDRIN, DIELDRIN, CHLORDANE AND HEPTACHLOR FOR INSECT CONTROL ON CORN AND APPLES

Excerpts from Study
Prepared by RvR CONSULTANTS Under
Subcontract to MIDWEST RESEARCH INSTITUTE

Contract No. 68-01-2448, Mod. #6
MRI Project No. 3920-C
RvR Project No. 69

In Iowa, Illinois, Ohio, Missouri, and South Dakota, aldrin led all other corn insecticides by wide margins. Estimates for Indiana are available only for all organochlorine, and for all organophosphate and carbamate insecticides combined, not disaggregated by individual products within each group.

The state estimates detailed in Table 1 are presented in summary form in Table 2. For purposes of Table 2, it was assumed that the share of individual insecticides within the organochlorine group and the organophosphate/carbamate group used in Indiana would be identical to the shares of these products in the group totals in the two neighboring states, Illinois and Ohio. Estimates for Indiana by individual products were derived by applying this assumption to the group totals reported by the extension entomologists.

One additional adjustment was made in preparing Table 2. When the insecticide quantity estimates from Table 1 were added up, the totals for the 3 organochlorine insecticides and for carbofuran appeared to be unrealistically high. We suspected and subsequently confirmed that most of the entomologists had made their estimates in terms of acres treated. Pesticide quantity estimates for 7 of the 8 states were then derived by multiplying estimated acres treated by the recommended rates per acre of the insecticides in question. Only the Minnesota quantity estimates are based on multiplying estimated acres treated by actual rates of use per acre as determined in a survey. Table 1 shows that in the case of aldrin, chlordane, and carbofuran, 3 of the 4 insecticides whose volume estimates we questioned, the rates per acre reported by Minnesota are substantially lower than those listed by the other 7 states.

In preparing Table 2, we used the following "estimated actual" insecticide application rates for the states other than Minnesota (all in pounds of active ingredient per acre): aldrin, 1.25; heptachlor, 1.3; chlordane, 2.0; carbofuran, 0.85. Due to these adjustments, most of the state estimates of the quantities of these 4 insecticides in Table 1 differ from those in Table 2.

Table 2 thus embodies the extension entomologists' estimates on the numbers of acres treated with corn insecticides in their respective states, and rates of application per acre for each insecticide verified and, where appropriate, adjusted by RvR Consultants.

Appendix B, Table 1--Soil Insecticides Used on Corn in Eight Midwestern States in 1974 by States, Products, Rates, Acres Treated, Total Quantities Used, and Target Insects

State	Insecticide	Rate Lb. a.i. / Acre	Acres Treated (1,000)	Total Used, 1,000 Lb. Act. Ingr.	Target Insect(s)
Iowa	Aldrin	2.0	2200.0	4400.0	Cutworms & Wireworms
	Furadan	1.0	875.0	875.0	Corn Rootworms
	Thimet	1.0	875.0	875.0	" "
	Bux	1.0	250.0	250.0	" "
	Dyfonate	1.0	250.0	250.0	" "
	Dasanit	1.0	175.0	175.0	" "
	Heptachlor	2.0	49.5	99.0	Cutworms & Wireworms
	Mocap	1.0	50.0	50.0	Corn Rootworms
	Landrin	1.0	25.0	25.0	" "
	Chlordane	3.0	5.5	16.5	Cutworms & Wireworms
Illinois	Aldrin	2.0	1798.3	3596.6	Cutworms & Wireworms
	Furadan	.75-1.0	1762.2	1497.9	Corn Rootworms
	Thimet	1.0	956.3	965.3	" "
	Dyfonate	1.0	733.7	733.7	" "
	Chlordane	3.0	204.5	613.5	Cutworms & Wireworms
	Heptachlor	2.0	270.6	541.2	" "
	Bux	1.0	222.5	222.5	Corn Rootworms
	Diazinon		1,750 bu.	164.1	Seed Treatment
	Dasenit	1.0	65.0	65.0	Corn Rootworms
Indiana	Aldrin Heptachlor Chlordane		1510.0	3500.0	Cutworms & Wireworms
	Furadan Thimet Bux Dyfonate Diazinon		660.0	660.0	Corn Rootworms
Ohio	Aldrin	2.0	500.0	1000.0	Cutworms & Wireworms
	Chlordane	4.0	100.0	400.0	" "
	Furadan	1.0	250.0	250.0	Corn Rootworms
	Thimet	1.0	150.0	150.0	" "
	Dyfonate	1.0	100.0	100.0	" "
	Carbaryl	2.0	32.0	64.0	Cutworms
	Diazinon	35,000 bu.	35,000 bu.	52.5	Seed Treatment
	Dasanit	1.0	50.0	50.0	Corn Rootworms
	Heptachlor	2.0	5.0	10.0	Cutworms & Wireworms
	Misc.	1.0	50.0	50.0	Corn Rootworms
Missouri	Aldrin	2.0	800.0	1600.0	Cutworms & Wireworms
	Furadan	1.0	105.0	105.0	Corn Rootworms
	Thimet	1.0	75.0	75.0	" "
	Dyfonate	1.0	60.0	60.0	" "
	Dasanit	1.0	30.0	30.0	" "
	Bux	1.0	30.0	30.0	" "
	Heptachlor	2.0	15.0	30.0	Cutworms & Wireworms
	Chlordane	3.0	5.0	15.0	" "
	Diazinon seed Treatment	140,000 bu.	140,000 bu.	13.1	Seed Insects
	Misc. seed treatment	20,000 bu.	20,000 bu.	1.3	" "
Minnesota	Furadan	.86	787.0	676.82	Corn Rootworms
	Thimet	1.14	176.0	200.64	" "
	Dyfonate	1.14	170.0	193.8	" "
	Dasanit	.95	165.0	156.75	" "
	Aldrin	.94	130.0	122.2	Cutworms & Wireworms
	Chlordane	1.6	71.0	113.6	" "
	Mocap	.84	88.0	73.92	Corn Rootworms
	Diazinon	1.0	30.0	30.0	" "
	Misc.		23.0		Complex

(Table concluded on next page)

Appendix B, Table 1--Soil Insecticides Used on Corn in Eight Midwestern States in 1974 by States, Products, Rates, Acres Treated, Total Quantities Used, and Target Insects (Concluded)

State	Insecticide	Rate Lb. a.i. / Acre	Acres Treated (1,000)	Totaled Used, 1,000 Lb. Act. Ingr.	Target Insect(s)
S. Dakota	Aldrin	2.0	220.0	440.0	Cutworms & Wireworms
	Furadan	1.0	250.0	250.0	Corn Rootworms
	Thimet	1.0	250.0	250.0	" "
	Dyfonate	1.0	250.0	250.0	" "
	Heptachlor	2.0	55.0	110.0	Cutworms & Wireworms
	Mocap	1.0	100.0	100.0	Corn Rootworms
	Dasanit	1.0	50.0	50.0	" "
	Diazinon	1.0	30.0	30.0	" "
	Bux	1.0	30.0	30.0	" "
	Misc.	1.0	40.0	40.0	" "
Nebraska	Furadan	1.0	1909.5	1909.5	Corn Rootworms
	Thimet	1.0	840.2	840.2	" "
	Dyfonate	1.0	305.5	305.5	" "
	Aldrin	2.0	140.0	280.0	Cutworms & Wireworms
	Dasanit	1.0	267.3	267.3	Corn Rootworms
	Bux	1.0	248.2	248.2	" "
	Diazinon	1.0	114.6	114.6	" "
	Misc.	1.0	133.7	133.7	" "
	Misc. Seed Treatment		1500.0	140.6	Seed Insects

AI = Active Ingredient

Source: Estimates by Extension Entomologists in each state (December, 1974)

Appendix B, Table 2--Soil Insecticides Used on Corn in Eight Midwestern States in 1974 By States and Products

Insecticide / State	Organochlorines			Organophosphates					Carbamates		
	Aldrin	Heptachlor	Chlordane	Phorate	Dyfonate	Dasanit	Diazinon	Mocap	Carbofuran	Bux	Carbaryl
	1,000 lb Active Ingredients										
Iowa	2,775	65	10	875	250	175	Negl.	50	745	250	Negl.
Illinois	2,250	350	410	955	735	65	155	Negl.	1,500	225	Negl.
Indiana	1,630	220	390	170	130	15	35	Negl.	265	35	10
Ohio	625	10	250	150	100	50	50	Negl.	215	Negl.	65
Missouri	1,000	20	10	75	60	30	15	Negl.	90	30	Negl.
Subtotal, "corn belt"	8,280	665	1,070	2,225	1,275	335	265	50	2,815	540	75
Minnesota	120	Negl.	115	200	195	155	30	75	675	Negl.	Negl.
S. Dakota	275	70	Negl.	250	250	50	30	100	215	30	Negl.
Nebraska	175	Negl.	Negl.	840	305	265	115	Negl.	1,625	250	Negl.
8 Midwest States	8,850	735	1,185	3,515	2,025	805	440	225	5,330	820	75

Source: Estimates by Extension Entomologists and by RvR Consultants (December, 1974)

APPENDIX C

MATHEMATICAL PROGRAMMING ANALYSIS OF C/H RESTRICTION

Introduction

An examination of issues relating to continuation or modification of established use patterns for pesticides must involve both the costs and benefits associated with each use. After the costs and benefits have been specified, society, or its designee thru public regulatory bodies, must determine if the benefits of the pesticide outweigh the costs. The decision is difficult and, if optimal, would require an exact specification of a number of elusive parameters associated with health and environmental effects, biological processes and measures of social welfare. In practice, these parameters cannot be precisely identified and therefore, society must base its decision on the best available information and documentation.

The costs are generally external to market activity and are, therefore, more difficult to accurately measure than are the corresponding benefits. These costs which potentially include such areas as generally worsening health of pesticide accident victims, subtle ecological insults with potential for disrupting the food chain as well as the acute health and environmental consequences associated with misuse or accidental exposure and contamination are not metered through the market system, thus negating a common market measure.

Further complicating the comparison of benefits and costs is the lack of precise knowledge regarding the biological questions associated with pesticides. Aside from the fact that the social costs stemming from pesticide use are normally of an external nature, biological scientists have been unable to answer such questions as how much cumulative ingestion of a persistent pesticide will cause ecological or health problems. Therefore, even the assignment of market values to nonmarket impacts is difficult because of the inexact nature of such impacts. In the face of such an imprecise measurement, the policy maker must apply his own judgement of the costs imposed on society and weigh his subjective determination against the best estimate of benefits derived by economists and pesticide use specialists.

In order to assist the policy maker in his role as social arbitrator of pesticide use, a mathematical model of U.S. agriculture was constructed to measure the benefits from pesticides and to specify the national and interregional impacts associated with changes in currently allowable use patterns.

Although of a different nature than those associated with cost measurements, the assessment of social benefits from pesticide use has several inherent problems. Benefit related problems are primarily data oriented and include such areas as accurate descriptions and quantification of use patterns, efficacy of alternative control agents and marginal productivity ratings for problem chemicals. A mathematical programming model for policy analysis cannot overcome these data deficiencies, but can provide a thorough analysis on a national and interregional basis of the best available information regarding yield and substitution impacts.

Due to a high degree of substitution between feedgrains when comparative advantage is modified and substitution between various types of land within a region and between regions, it is difficult to assess and predict the national and interregional impacts stemming from major changes in input availability and technology within a partial equilibrium analysis, i.e. analysis of only one feedgrain sector or one geographic region. Therefore, a national-interregional, mathematical programming model of the U.S. agricultural sector was constructed to evaluate the overall changes in production of endogenous crops, changes in return to land, modifications in livestock rations and adjustments in interregional trade resulting from alteration of available pest management alternatives.

The version of the mathematical programming system used to evaluate the C/H cancellation consists of a base linear programming matrix with approximate dimensions equalling 28,000 columns by 2,500 rows. The models were solved using the MPS/III mathematical programming algorithms on an IBM 370/168 computer. Model aggregation consists of 127 production regions for which all production activities are defined and 27 consuming regions for which final demands are specified. Model solutions are reported for the individual consuming regions, seven aggregate U.S. subregions, and U.S. totals.

Linear Programming Model of U.S. Agriculture

The specific form of the mathematical programming model which was constructed to aid in the evaluation of C/H restriction is a cost minimization, optimization model with linear resource restraints and an objective function which is both linear and additive. While linear assumptions do not always mirror real world situations, the techniques employed in the development of this model enable the application of linear programming techniques to nonlinear areas.

The model is national in that it recognizes that markets for agricultural products are national (individual producing regions are not isolated from one another), while the regional delineation of producing areas (127 in total) accounts for the unique physical relationships which are a function of the location of agricultural production (soil type and yield, climate, pest infestation, etc.). This construction places extreme emphasis on the economic phenomenon of interregional competition which is an important characteristic of the agricultural economy.

Seven crops are treated as endogenous to the model: barley, corn, cotton, soybeans, oats, sorghum and wheat. Other agricultural land uses are projected exogenously and subtracted from the total land base. The livestock sector is also projected exogenously and fixed at a predetermined level. The nonfeedgrain portion of total nutrient demand, stated as digestible protein (DP) and total digestible nutrients (TDN) for ruminants, nonruminants and poultry supplied from exogenous crops and land uses is subtracted from total nutrient demand to yield a set of net demands which must be satisfied through feeding of the endogenous feed grains. Other nonfeeding demands such as barley malt for brewing, corn for breakfast cereal, etc., are projected as a function of Series E population estimates and are added to regional demands to form the right hand side constraints which must be satisfied by endogenous production. A set of activities for production of the endogenous crops by region with variable yields disaggregated by nine soil classes define the feasible set of activities which can be used to satisfy regional and export demands (estimated exogenously). Each production activity has a corresponding budget and yield. The budgets, which are disaggregated by variable input, e.g., labor, fertilizer, pesticides, machinery, allow the analyst easy access to the model for purposes of updating or changing the cost and/or quantity of variable inputs.

Linkage between the production activities and demand constraints is provided by feed conversion activities (the DP and TDN equivalent of each endogenous crop as defined by NRC specifications) and transportation activities to allow interregional movement of endogenous crops to meet the fixed, regional demands.

The model is solved through a mathematical algorithm which simutaneously guarantees that: a) all regional demands are satisfied, b) no regional resource constraints, e.g., disaggregated land base is exceeded, and c) the objective function is minimized. In so doing, the model solution depicts the land use and production pattern which satifies all constrants at least cost.

An alternative construction would have been a profit maximization model which would provide a solution to maximize returns to the agricultural sector. However, a unique characteristic of linear programming analysis guarantees that the dual solution of a cost minimization model is a profit maximization solution; therefore the activity levels for both cases are identical. The cost minimization formulation was chosen on the basis of modelling criteria which lend nothing to the accuracy or validity of the solution.

Pesticide Analysis - A Special Case of the General Agricultural Model

To be useful for short run policy analysis (a projection within a five-year horizon), the first criterion for a mathematical programming model is that it be believable. Major drawbacks in previous national agricultural models have been their sensitivity to minor changes in input coefficients and/or their overall sensitivity to misspecification. Many previous models have offered solutions for agricultural equilibrium in the future, such as 1985-2000 and, in these cases, solutions from the model which suggest drastic shifts away from observed patterns of land use and production are difficult to evaluate.

A number of arguments are put forward to explain the differences between long run model solutions and short run historical observations. In the first instance, one can hypothesize that the long run solution from an LP model is correct and that changes in comparative advantage will lead to major shifts in production patterns between regions. Secondly, one can argue that any given glimpse of agricultural production patterns (a one-year historical pattern) depicts the system in disequilibrium and, in the long run, farmers will follow the profit maximization (or cost minimization) motive and trend toward model solutions. A third, but trivial argument supporting long run, major deviations from observed production patterns professes the argument that, in the long run, all factors are variable and mobile and, therefore, model results are believable. This argument suggests that the long run is represented by an unknown which cannot be assessed through examination of historical observation.

A more believable scenario for long run deviations from history lies in the labyrinth of farmers' decision making. Unlike a mathematical program which recognizes one-cent changes in the profitability of one crop versus another and suggests appropriate adjustments to attain general equilibrium conditions, farmers are incapable of discerning small, permanent changes in relative net returns. The magnitude of annual fluctuations in prices and yields due to natural, stochastic phenomena such as weather plus temporary market fluctuations due to short term variables like trade adjustments make long term, permanent changes in comparative advantage difficult to discern. In addition, an incorrect guess based on limited data is often more costly than the failure to immediately adjust to permanent changes. Therefore, farmers may tend to resist change when a system of equations suggests that change should occur. In the long run, if the stimuli remain, both the real world solution and a well specified model should converge on the same equilibrium pattern.

Significant effort was expended toward making the EPA pesticide model believable in the sense that it "tracks well" with historical production patterns. In order to evaluate phenomena which are location specific, e.g., pest infestations and pesticide applications, the base linear programming solution must coincide with the patterns of land use from the most recent historical period. To assure as much realism as possible, all data relating to land use and past production was either gathered at the county level or disaggregated to the county level prior to aggregation up to production regions. Detailed statistical procedures were used to forecast land use (planted acres) and yield for the endogenous crops. These projections, for the seven endogenous crops in each of the 127 producing regions, served as target activity levels which were, by construction, consistent with historical trends.

Deviations from these "P" (projected) activities had associated costs to represent the basic stability of the U.S. agricultural system and to model the fact that farmers are: a) unable to discern and respond to small changes in comparative advantage in the short run, b) somewhat inflexible in their production decisions, and c) consider long run vs. short run production costs when deviating from past patterns. These costs, termed flexibility costs, while not unique in theory are operational only in the EPA national agricultural model.

As an indication of the ability of the EPA model to generate solutions which are consistent with historical trends, a comparison was made between statistical projections for 1977 based on twenty-five years of time series data and the linear programming solution for 1977 (Table 1).

To evaluate the impact of restricting the use of chlordane and heptachlor, the land base in corn growing regions had to be disaggregated by insect infestation. Regional acreage estimates were made of infestations of cutworm, wireworm and rootworm. The model's distribution of infested acres is reported in Table 2. Infestations were further disaggregated by soil productivity class to enable interaction between the yields associated with various soils and crop loss due to infestations. Base model solutions for treated acreage (as opposed to infested acreage) are reported in Table 3. As Table 3 indicates, chlorinated hydrocarbon insecticides are the primary control agent on cutworm infested land while other insecticides, in addition to chlorinated hydrocarbons, are used to control rootworms and wireworms.

Evaluation of the impact of C/H restriction requires a system of comparative statics where the solution in the base model which allows C/H use is compared to the solution of a second model with C/H use options excluded from the feasible set of production activities. To accomplish this, several assumptions were required to define the parameters for specification of the second model.

Appendix C, Table 1--Comparison of time series projection for endogenous crops, 1977 and LP solution for 1977

Crop	Projection	Model Solution
	---------million acres----------------	
Barley	13,848	12,320
Corn	53,847	49,900
Cotton	7,979	9,450
Soybeans	53,519	59,940
Oats	14,551	8,820
Sorghum	15,167	15,210
Wheat	68,855	69,790
Slack land	29,086	31,260

Appendix C, Table 2--Base model distribution by insect species, of infested corn

State	Insect Species		
	Wireworm	Rootworm	Cutworm
	------------million acres--------------		
Ohio	0.19	0.51	0.43
Michigan	0	0.71	0
Indiana	0.34	1.43	0.46
Illinois	1.09	2.87	1.21
Missouri	0.32	0.57	0.59
Iowa	0.57	3.63	0.87
Wisconsin	0	1.09	0.34
North Dakota & Northern Minn.	0.01	0.19	0.02
South Dakota & Southern Minn.	0.40	1.82	0.45
Nebraska	0	4.06	0.19
Kansas	0.16	0.43	0.16
Total	3.08	17.31	4.72

Source: EPA Linear Programming Analysis.

Appendix C, Table 3--Base model distribution of corn acreage infested by wireworm, rootworm and cutworm by treatment option

State	No Treatment	Other Pesticides	Chlorinated Hydrocarbon
Ohio			
Wireworm	0	0	.17
Rootworm	.03	0	.39
Cutworm	.12	0	.16
Total	.15	0	.72
Michigan			
Wireworm	.23	.13	.25
Rootworm	0	0	0
Cutworm	0	0	0
Total	.23	.13	.25
Indiana			
Wireworm	.05	.01	.28
Rootworm	.61	.07	.72
Cutworm	0	0	.36
Total	.66	.08	1.36
Illinois			
Wireworm	.1	.37	.49
Rootworm	.09	.93	1.0
Cutworm	.03	.03	.83
Total	.22	1.33	2.32
Missouri			
Wireworm	.03	.07	.11
Rootworm	.06	.18	.14
Cutworm	0	0	.45
Total	.09	.25	.70
Iowa			
Wireworm	.04	.26	.11
Rootworm	.01	2.33	.71
Cutworm	0	0	.54
Total	.05	2.59	1.36
Wisconsin			
Wireworm	0	0	0
Rootworm	.21	.77	0
Cutworm	.02	0	0
Total	.23	.77	0

Appendix C, Table 3 (Continued)

State	No Treatment	Other Pesticides	Chlorinated Hydrocarbon
Minnesota (N)			
Wireworm	0	.01	0
Rootworm	0	.08	0
Cutworm	0	0	.01
Total	0	.09	.01
Minnesota (S)			
Wireworm	.13	.13	.02
Rootworm	.11	1.15	.07
Cutworm	.23	0	.12
Total	.47	1.28	.21
Nebraska			
Wireworm	0	0	0
Rootworm	.16	2.26	.02
Cutworm	.06	0	.09
Total	.22	2.26	.11
Kansas			
Wireworm	.04	.05	0
Rootworm	.02	.21	0
Cutworm	.05	0	.04
Total	.11	.26	.04
Total	2.53	9.07	7.12

Table Note: Individual columns may not total due to rounding error.

Source: EPA Linear Programming Analysis.

In general, the parameters were chosen such that the model would depict a "worse case" impact associated with restrictive public action. The decision to model an extreme case was made for the following reasons. First, the decision makers who must weigh costs and benefits must be cognizant of the full range of potential impacts. If, in their weighing of costs and benefits they can determine that the costs associated with continued use exceed the derived benefits under maximum benefit conditions, the appropriate social strategy is more clearly defined. Data and evaluation which provide the spectrum of use associated benefits under a "most likely" set of assumptions is also necessary to decision making and will be provided after subsequent model solutions are generated. Secondly, a USDA sponsored study (Delvo, 1974) derived yield impacts associated with chlorinated hydrocarbon restrictions for the three endogenous insect species under several assumptions regarding alternative controls. As Delvo points out, the yield impacts are representative of "what might occur with a moderate to heavy insect infestation." A corollary set of assumptions for a typical year has not yet been fully specified. Therefore, the available data also played a role in choosing to model the extreme situation first.

Explicit assumptions in the chlorinated hydrocarbon exclusion model included the areas treated with C/H during the base year (1977) and yield impacts associated with C/H withdrawal. The assumption was made that following the recent aldrin/dieldrin suspension, C/H would fill the void created by other chlorinated hydrocarbon withdrawals. Therefore, the expected use of C/H could be stimulated by examining the most recent estimates of total aldrin, dieldrin, chlordane and heptachlor use. To the extent that other chemicals in addition to C/H fill the void created by restrictions in aldrin and dieldrin, the current model overestimates C/H use and therefore overestimates derived benefits from C/H use (costs associated with cancellation). Yield inputs, with the exception of those associated with rootworm treatment, were assumed to be at the level reported by Delvo. Delvo did not specify yield impacts on rootworm treated land other than to assume "that corn yield would not change if alternative insecticides were used to replace aldrin for corn rootworm control" (p. 6). He further states that "there is some indication, from Illinois data, that yields may increase if nonorganochlorine insecticides are substituted for aldrin in corn rootworm control" (p. 6). Further examination of this issue by entomologists in C&E Division indicates that, due to widespread rootworm resistance to organochlorines, the increased yields associated with shifting from organochlorines to other pesticides may be significant and is not unique to Illinois. As a starting point, the parameters for rootworm damage in the restrictive model specify a 15 percent yield decline if no insecticides are used to replace chlorinated hydrocarbons on previously treated rootworm land and an 8 percent yield decline if C/H is used in place of other pesticides. In other words, it was assumed that the use of other pesticides would produce state yields while the use of C/H would lead to 8% yield declines on rootworm infested acreage. The full yield file is reported in Table 4.

Table 4 -- Impact of restriction in chlorinated hydrocarbon insecticide use by species.

State	species:	Cutworm		Wireworm		Rootworm	
	option:	w/alt.*	w/o alt.*	w/alt.	w/o alt.	w/alt.	w/o alt.
	---------percent change from state yield---------						
Ohio		-5	-10	0	-10	0	-15
Indiana		-10	-25	0	-10	0	-15
Illinois		-10	-25	0	-10	0	-15
Iowa		-10	-25	-8			
Missouri		-15	-30	-8	-12	0	-15
Lake States & Northern Plains		-10	-25	-8	-12	0	-15

Source: EPA Linear Programming Analysis

* w/alt. = alternative pesticides.
w/o alt. = without alternative pesticides.

APPENDIX D
ASSUMPTIONS USED TO DERIVE ENERGY IMPACT OF CANCELLATION

Assumption used to derive energy impact of cancellation

Text tables 21 and 22 summarize the energy impact of cancellation of chlordane and heptachlor based on representative substitutes: carbofuran, diazinon, and carbaryl. Carbofuran, a member of the carbamate class of pesticides, is the major substitute. Diazinon is an important substitute among the organophosphate pesticides. It was chosen also for its chemical complexity. Carbaryl is an inexpensive and widely available carbamate.

Below is a list of the important assumptions made in developing Tables 21 and 22. These are followed by remarks on the influence of some general factors.

Assumptions:

1. A private study on chlordane and heptachlor energy requirements was used to derive energy impacts (Syracuse University Research Corporation). Comparing process steps, the energy and electricity requirements from this study were extrapolated to the three substitute pesticides selected -- carbofuran, diazinon, and carbaryl.

   The dicyclopentadiene feedstock for chlordane and heptachlor was assumed to be obtained at no energy cost. The energy costs for the chlordane feedstock were calculated thermodynamically as 3.44 kWh/lb chlordane and 2.82 kWh/lb heptachlor, respectively.

   For the three substitute insecticides considered, the feedstock chemicals were traced back to natural raw products or petroleum distillates, with appropriate process energy (electricity and heat) assigned to each step.

2. The use as representative was that of a soil insecticide on corn and potatoes.

3. None of the feedstock chemicals are obtained as by-products of other chemicals. Rather, each has its own independent market and production economics. An exception was made in the case of chlorine. Invariably produced with caustic soda, chlorine was assigned only half its actual energy requirement.

   The assumption that each feedstock chemical is produced in a distinct, independent process is in error. We were unable to evaluate the direction of the error in estimating the impact of the studied pesticides on petroleum consumption. The American chemical industry is often able to accommodate supply and price fluctuations despite joint production. Felicitous by-product relationships are common, often by design. For example, phenol, raw material for carbofuran, can be made with either chlorine and caustic acid or propylene. If made with the latter, a by-product is acetone, which in turn is a raw material for diazinon production.

4. Similarly, in calculating "petroleum for feed" in Tables 21 and 22, it was assumed that petroleum processing can be adjusted to produce one pound of the feedstocks from one pound of crude oil. Since only about 10% of petroleum distillates go to petrochemicals, and around 7% of petrochemicals (by weight) are pesticides, this assumption may be valid even over a short run.

   Despite abundance of divertible petroleum, shortages of particular chemicals may occur, either because of allocation or limited facilities, or because joint processes tie production of some materials to that of others. The effect might be a larger impact on petroleum consumption than estimated here. On the other hand, carbaryl does not demand a petroleum base. Its increased use could balance such an underestimate. Also, phorate, another major organophosphate, requires less petroleum than diazinon. Since diazinon was taken as the representative organophosphate, if phorate were the substitute, petroleum use would be less than estimated here.

5. The mode of application was assumed similar for the substitute, for example, soil incorporation and spraying (see Assumption 11 on following page). Amounts are from entomologists' recommendations published in Report No. 68-01-2448 (6), RvR Consultants.

   Based on active ingredient:

   Diazinon -- 1.3 lb/lb heptachlor; 0.65 lb/lb chlordane.

   Carbaryl -- 1.0 lb/lb heptachlor; 0.5 lb/lb chlordane.

   Carbofuran -- 0.5 lb/lb heptachlor; 0.25 lb/lb chlordane.

6. It was assumed that each insecticide is applied one time per season, with no fuel cost to apply (e.g. no tractor fuel). Thus, only manufacturing energy impact was calculated.

7. Cyclopentadiene, phenol, naphthol, and ethanol, which are feedstock materials for chlordane-heptachlor, carbofuran, carbaryl, and diazinon, respectively, may be preduced in large quantities from coal. Only the petroleum source was considered, however.

8. The "total substitutes" impact in the Tables was calculated taking diazinon (a typical organophosphate), carbofuran, and carbaryl in the ratio 7:7:1. It was chosen after consulting with economists, and taking into account use patterns given in Project Reports #P4-01-03990, 14 Nov. 1974 (T. Reideburg Assocs.) and #68-01-2448(6) (RvR Consultants).

9. The following conversion factors were taken from Chapter 9 of "Chemical Engineers' Handbook", by J.H. Perry, McGraw-Hill, 1963: coal 13,000 btu/lb; oil 140,000 btu/gal; 7 lb/gal, 42 gal/bbl, 294 lb/bbl; boiler heat 11,500 btu/kWh, 1100 fuel btu/lb steam.

10. Process solvent consumption was ignored. Rather, recovery was assumed. A quick calculation assuming 5% loss of benzene-like solvent gave an increase in "Petroleum for feed and inerts", "Total substitutes" of 10% for chlordane, and 20% for heptachlor.

11. "Petroleum for inerts" was calculated assuming granular and wettable powder forms, except diazinon, contain no petroleum inerts.

    The inerts were weighted as follows, based on estimated patterns supplied by Illinois Agr. Extension: chlordane, heptachlor, carbofuran, and carbaryl -- negligible. Diazinon AG500 (46% inert) x 100% use = 45% inerts.

12. The effect on natural gas consuption was not considered. Natural gas was assumed to be of secondary importance as an industrial energy source. To convert coal in the Table to natural gas, assume 12.5 cu ft of gas per lb coal.

    Remark: It is assumed that all other petroleum and energy-saving measures with higher benefit/cost indices have been taken. Energy expense in exchange for decreased human hazard is to be balanced against alternative uses for the same energy.

    Further, it is assumed that patterns of crop cultivation and transportation, and attendant energy use, will not change as an economic consequence of cancellation.

APPENDIX E

Table 1: SUMMARY OF REGISTERED CHLORDANE AND HEPTACHLOR SUBSTITUTES FOR SELECTED DOMESTIC, COMMERCIAL, PUBLIC HEALTH AND MISCELLANEOUS USES

Appendix E, Table 1.

Summary of Registered Chlordane and Heptachlor Substitutes for Selected Domestic, Commercial, Public Health and Miscellaneous Uses

Crop or Site of Applications	Insect Pests	Total No. Pests	No. of Registered Pest Substitutes				Remarks
			0	1-5	6-10	10+	
Home, Garden, Ornamental and Shade trees	Ants, bagworm, blockvine weevil, Larvae, Circket, Earwigs, Elm Leaf beetles, Fuller's Rose beetle, Grasshoppers, Fire Ant (mound treatment), Lale bugs, Leafminers, Leafrollers, Narcissus bulbfly, white Grubs, Wireworms, Strawberry root weevil, Rough Strawberry Rootweevil, Bulb Fly, Tent Caterpillars Tree Crickets, borers, Thrips	23	6	11	3	3	Dieldrin is the only Registered Alternative for Crickets, Earwigs, Grasshoppers
Agricultural Premises, Dairy Barns, Poultry Houses	Houseflies	1			1		
Ditch Banks, Field Borders, Roadsides, Vacant Lands	Chiggers, Flies, Gnats, Mosquitoes Ticks, Grasshoppers, Crickets	7		7			In general, Toxaphene baits are registered for many of the same uses as Chlordane baits
Baits	Grasshoppers, Cutworms, Crickets, Molecrickets	4		4			

Table 1 (Continued)

Crop or site of applications	Insect Pests	Total No. Pests	No. of Registered Pest Substitute				Remarks
			0	1-5	6-10	10+	
Termite control for buildings, homes and industry	Termite	1			1		Lindane and aldrin/dieldrin are registered substitutes
Lawns/turf and nursery soil and surface applications:	Armyworm, Ant, Asiatic garden beetle larvae, Boxelder bug, Chiggers, Chinch bug, Cicada killer, Wild bees, Cutworms, Earthworms, Earwigs, European chafer larvae, Green June beetle larvae, Japanese beetle larvae, Lawn moths, Mosquito adults, Ticks, White-fringed beetle larvae, Wireworms, White grubs, Imported fire ants, Grasshoppers, Black vine weevil, Fleas, More crickets, Pillbugs, Snails, Sowbugs, Striped grassworm, False wireworm, Europe crane fly	31	11	15	4	1	Diazinon registered as an alternative for most pests for which alternatives are available

Table 1 (Continued)

Crop or site of applications	Insect Pests	Total No. Pests	No. of Registered Pest Substitutes 0	1-5	6-10	10+	Remarks
Household and animal sprays and dusts	Ants, Boxelder bug, Brown dog tick, Carpet beetle, Centipedes, Crickets, House-flies, Mosquitoes, Roaches, Waterbugs, Scorpions, Spiders, Silverfish, Wasps, Firebrat, Oldhouse borer, Powderpost beetles	17	3	13	1		
Dogs	Lice, Fleas, Ticks, Sarcoptic mange	4		4			
Herbicide	Preemergence Crabgrass Control	1		1			Benefin, Siduron, Dacthal, Betasan, Zyton are registered
Special uses:	Mosquito larvae (Public Health), Psychoda flies, Dog and cat lice, Fleas, Ticks and mange, Field treatment of fire ants, Forestry plantations--white pine weevil	5	2	3	1		There are no registered alternatives for use against white pine weevils.

Table 1 (Continued)

Crop or site of applications	Insect Pests	Total No. Pests	No. of Registered Pest Substitutes				Remarks
			0	1-5	6-10	10+	
Seed treatments							
Barley, Beans, Blackeyed Peas, Corn, Cotton, Cowpeas, Oats, Peas, Rice, Rye, Sorghum, Soybeans, Wheat	Corn rootworms Seedcorn beetle Seedcorn maggot Wireworms False wireworms Kafir ant Rice water weevil	13		13			

Sources: Fredrick Hageman, Preliminary Summary of Registered Chlordane and Heptachlor uses and Alternatives, Ecological Effects Branch, Criteria and Evaluation Division, Office of Pesticide Programs, EPA, 1974; also, use matrices for Chlordane/Heptachlor and Aldrin/Dieldrin prepared by Ecological Effects Branch, Criteria and Evaluation Division, OPP, EPA, 1974. Heptachlor "A Review of its uses, Chemistry, Environmental Hazards, and Toxicology", Environmental Protection Agency, 1974; "Pesticide Aspects of Chlordane in Relation to Man and the Environment," 1972. "Pesticidal Aspects of Chlordane and Heptachlor in Relation to Man and his Environment--Further Review," 1972-1975.

APPENDIX F

FEDERAL REGISTER NOTICE OF EPA ADMINISTRATOR'S INTENT TO CANCEL CERTAIN REGISTERED USES OF CHLORDANE AND HEPTACHLOR

November 26, 1974

[Docket No. 27181]

SERVICE TO STOCKTON CASE

Prehearing Conference

Notice is hereby given that a prehearing conference in the above-entitled matter is assigned to be held on January 7, 1975, at 10 a.m. (local time) in Room 1031, North Universal Building, 1875 Connecticut Avenue NW., Washington, D.C., before Administrative Law Judge Greer M. Murphy.

In order to facilitate the conduct of the conference, parties are instructed to submit one copy to each party and four copies to the Judge of (1) proposed statements of issues; (2) proposed stipulations; (3) requests for information; (4) statement of positions of parties; and (5) proposed procedural dates. The Bureau of Operating Rights will circulate its material on or before December 13, 1974, and the other parties on or before December 27, 1974. The submissions of the other parties shall be limited to points on which they differ with the Bureau of Operating Rights, and shall follow the numbering and lettering used by the Bureau to facilitate cross-referencing.

Dated at Washington, D.C., November 21, 1974.

[SEAL] ROBERT L. PARK,
Chief Administrative Law Judge.

[FR Doc.74-27443 Filed 11-25-74;8:45 am]

ENVIRONMENTAL PROTECTION AGENCY

[FRL 296-8]

PESTICIDE PRODUCTS CONTAINING HEPTACHLOR OR CHLORDANE

Intent To Cancel Registrations

On March 18, 1971, the Administrator of this Agency announced that active internal review was being initiated on a number of pesticide products, including those containing chlordane and heptachlor. As the result of such review and for the reasons set forth in the attached statement of reasons, I find that the continued registration and use of these pesticides appear to pose substantial questions of safety amounting to an unreasonable risk to man and the environment. I therefore serve and file this notice of intent, together with the attached statement of reasons, to cancel all registered uses of heptachlor and chlordane within thirty (30) days, pursuant to section 6 of the Federal Insecticide, Fungicide, and Rodenticide Act, As amended, (86 Stat. 973, 7 U.S.C. 136d), with the exception of the use of heptachlor or chlordane through subsurface ground insertion for termite control and the dipping of roots or tops of nonfood plants. Any affected party may contest this action by requesting a hearing on specific registered uses on or before December 26, 1974. Requests for hearings should be submitted to the Agency's hearing clerk at the following address:

Mrs. Betty J. Billings
Hearing Clerk
U.S. Environmental Protection Agency
Room 1019, Waterside Mall—East Tower
401 M Street, SW.
Washington, D.C. 20460

The proposed cancellation shall become final and effective thirty (30) days from the date of this notice as to those registered uses for which a hearing is not requested by any affected party. The proposed cancellation shall not take effect regarding any registered use for which a hearing is requested until the hearing has been completed, unless there is a concurrence from all parties to the proceeding. The Agency reserves the opportunity to present evidence on any registered use affected by this order regardless of whether or not a hearing has been requested on that use, or whether or not such use is to be actively defended in the hearings.

Dated: November 18, 1974.

RUSSELL E. TRAIN,
Administrator.

STATEMENT OF REASONS: HEPTACHLOR AND CHLORDANE

I. LEGAL AUTHORITY

Section 6(b) of the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136 et seq) as amended (7 U.S.C. 136a(c)(5)(D)) authorises the Administrator of the Environmental Protection Agency (or his designee) to issue a notice of intent to cancel the registration of a pesticide or to hold a hearing "[i]f it appears to the Administrator that a pesticide or its labeling * * * does not comply with the provisions of this act or, when used in accordance with widespread and commonly recognised practice, generally causes unreasonable adverse effects on the environment * * *." The phrase "unreasonable adverse effects on the environment" is defined in section 3 of the Act (7 U.S.C. 136(bb)) as "any unreasonable risk to man or the environment taking into account the economic, social, and environmental costs and benefits of any pesticide."

The Act also prohibits the sale of pesticides which are misbranded. A product is considered misbranded if the label does not contain directions for use and a warning or caution statement which are necessary and if complied with are adequate to protect health and the environment. (7 U.S.C. 136(a)(1)(F) and (G).)

II. CHEMISTRY OF HEPTACHLOR AND CHLORDANE

Heptachlor and chlordane are chlorinated hydrocarbon insecticides, and have a chemical structure which is similar to that of Aldrin and Dieldrin. Both pesticides consist of a complex mixture of compounds whose ratios in the final technical product have been standardized. Technical heptachlor consists primarily of pure heptachlor (70–73 percent), gamma-chlordane (20–23 percent), nonachlor (4.5–5 percent), and small amounts of both the initial reactant (hexachlorocyclopentadiene) and chlorene. Technical chlordane consists primarily of approximately equal amounts of alpha-chlordane and gamma-chlordane (total: 43±5 percent), pure heptachlor (10±3 percent), nonachlor (8±3 percent), chlordene isomers (21±4 percent), and a number of other compounds in varying lesser amounts.

Both heptachlor and chlordane form toxic metabolites (including heptachlor epoxide, chlordene epoxide and oxychlordane) which are found in the urine and feces of mammals. Chlordene epoxide may also be formed by soil organisms. In addition, a caged isomer more toxic to insects and fresh water animals than heptachlor has been shown to be formed on exposure of heptachlor to sunlight. Oxychlordane, a major metabolite of chlordane, found primarily in animals (including man), is formed very slowly in normal liver tissue. Its formation, moreover, is accelerated by the presence of compounds such as DDT, dieldrin, or heptabarbital.

III. USES

Heptachlor and chlordane have been used extensively in the United States since the 1950's. In 1971, 70 percent of the approximately one million pounds of heptachlor used in U.S. agriculture was as a soil treatment for a wide variety of crops. Its primary use was on corn but also included vegetables, cereals, forage crops, seed crops, and seed treatments. The remaining 30 percent was used for the protection of commercial and residential structures against termites and for a variety of nursery, lawn, and garden applications, and for foliar application to ditch banks, roadsides and vacant fields. Total use of heptachlor more than tripled in 1972, of which over 1.7 million pounds was used for termites and structural pest control alone, and 1.6 million pounds was used on agricultural crops. It is estimated that the use of heptachlor on corn alone could increase to 3 million pounds in 1975.

Chlordane is used in much greater quantities than heptachlor, and is one of the most widely used household and garden pesticides. The quantity used has increased from approximately 11 million pounds in 1971 to between 15–16 million pounds in 1972. About 60 percent of the 1972 volume was used for termite control and other household and commercial applications, including crabgrass control, use on shade trees and ornamentals, and treatment of indoor pests. An additional 6.5 million pounds were applied to corn, grain, fiber and forage crops, and a variety of fruits and vegetables. Chlordane is also used as a seed treatment and in summer months is applied directly to water in sewage treatment plants for control of *Psychoda* larvae.

IV. ALTERNATIVE PESTICIDES

There are alternative pesticides registered for virtually all of the registered uses of both heptachlor and chlordane. As registered alternatives, these pesticides should be effective although there may be geographical areas or special situations where this is not true. Many of these substitutes may be more expensive than heptachlor and chlordane. In addition, most are less persistent, although persistence is frequently not a critical factor in terms of efficacy. In the case of subsurface termite control, however, persistence is critical. Aldrin and dieldrin are the principal other persistent pesticides presently registered for subsurface application for termite control. These uses of aldrin and dieldrin were not included in the recent suspension order of the Administrator nor in the cancellation action now pending.

Although some alternatives may be more acutely toxic than heptachlor and chlordane, hazards to applicators may be minimized by adherence to labeling instructions and other regulations, with the benefit of eliminating the chronic effects of heptachlor and chlordane.

We do not now have information on the usefulness of nonchemical control methods for each of the registered uses of chlordane and heptachlor but these methods should be thoroughly explored in the hearing.

V. TOXICITY

Heptachlor and chlordane are chlorinated hydrocarbon pesticides which are broad spectrum pesticides and are toxic to nontarget organisms as well as to insect pests. Reductions in bird populations following application of heptachlor to an area have been reported frequently. It is difficult, however, to determine what impact these toxicities have on species populations, as opposed to individual fish or wildlife or specific local populations.

Heptachlor and chlordane have demonstrated toxic effects which may have significant adverse effects on human health. Heptachlor and its metabolite, heptachlor epoxide, have been found to increase significantly the incidence of liver tumors including carcinomas in one strain of mouse (C3Heb/Fe/J) at a single feeding level of 10 ppm. The majority of these tumors were originally reported as benign. On the basis of the original reported experiment the Carcinogenicity Panel of the HEW Secretary's Commission on Pesticides and their Relationship to Environmental Health judged heptachlor epoxide "positive for tumor induction on the basis of tests conducted adequately in one or more species, the results being significant at the 0.01 level." Subsequent analysis by pathologists revealed a high incidence of carcinomas in animals from the experiment (greater than 90 percent incidence in animals given heptachlor epoxide).

In addition a two-year feeding study of heptachlor expoxide to 225 CFN rats showed a significant increase in the number of animals with tumors at the 0.5 ppm feeding level, and for all test animals at all feeding levels (0.5 ppm to 10 ppm) when the groups were combined. The tumors were found primarily in the endocrine organs, but a substantial number of liver tumors were found in the treated animals while no liver tumors developed in the control group.

There is evidence of embryotoxicity on the part of both heptachlor and chlordane to some strains of rats or mice. Embryotoxicity is of particular importance since heptachlor epoxide residues have been detected in human fetuses and neonates. There is additional evidence in the literature indicting other toxic effects of a chronic nature attributable to heptachlor and chlordane. All such evidence should be further explored in the hearings.

Since technical chlordane generally contains 8 to 12 percent heptachlor, all of the findings reported above for heptachlor and its metabolites are relevant to technical chlordane when adjusted for the difference in concentration. Pure alpha and gamma chlordane without heptachlor are not registered as a pesticide nor is the Agency aware of the existence of adequate efficacy data to satisfy registration requirements. Sufficient testing has not yet been completed or reported on highly purified chlordane to warrant a determination of the carcinogenicity of pure chlordane (without heptachlor).

VI. ENVIRONMENTAL CONTAMINATION AND PERSISTENCE

Heptachlor and chlordane, or their metabolites, are persistent in the environment long after use. Residues of heptachlor epoxide have been detected in soil samples for as long as ten years after application. Chlordane is even more persistent, with 18–20 percent of the originally applied dosage recoverable in soil ten years after application. In addition, heptachlor is quite volatile. Chlordane is also volatile, though somewhat less so than heptachlor. Chlordane vapors can penetrate packaging material and contaminate food in homes in which it is used.

Although we do not have data which can be considered representative of the ambient air nationally, limited sampling of sites selected for other purposes showed the presence of heptachlor, and to a very limited extent, chlordane. This indicates that air can be a source for human intake of these compounds.

As persistent compounds, heptachlor, chlordane, and their metabolites are subject to considerable movement from the site of actual application. Residues of both heptachlor and chlordane can be picked up from the soil and translocated to various parts of plants. Remnant residues are particularly significant in root crops such as carrots, potatoes, and beets. In addition, residues of chlordane were detected in alfalfa growth sampled at 2 months, 4 months, and 1 year after application to soil, at a dosage of 5 to 10 pounds actual chlordane per acre. One of the major residues found in alfalfa was oxychlordane (17 percent).

Although low in water solubility, their affinity for lipids and their ability to adhere to particulate matter make heptachlor and chlordane subject to bioaccumulation and transfer in the food chain, particularly in aquatic species. While heptachlor and chlordane would appear to be relatively immobile once they are bound to the soil, C_{14} labeled pesticides from treated fields east of Dallas, Texas, were monitored and later found to have been deposited by rain over Cincinnati, Ohio. The dust deposits contained 0.5 ppm chlordane. Treated soil is also subject to water erosion, ultimately leading to aquatic contamination, including contamination of phytoplankton and fish.

Chlorinated hydrocarbon pesticides have been detected in surface waters in concentrations of 10–150 ppt. Heptachlor concentrations in the Upper Mississippi and Missouri River Basins were all in the parts-per-trillion range and in many river basins of the country, ranged between 5–30 ppt. Heptachlor epoxide concentrations have ranged between 5–40 ppt.

Heptachlor, heptachlor epoxide and chlordane residues have been found frequently in fish, birds, and other wildlife. Heptachlor epoxide has been detected in birds at levels of 0.01–1.0 ppm. Chlordane residues in fish have generally been less than 0.5 ppm. Bluegill growth was reduced in heptachlor-treated ponds at a concentration in the water of 0.05 ppm. Heptachlor and heptachlor epoxide residues of 0.01–8.46 ppm were found in fish from the Great Lakes area.

Heptachlor epoxide has also been discovered in the tissues of several mammals, including pronghorn antelope (0.03 ppm), and mountain goats in South Dakota (0.12 ppm), which is indicative of its widespread distribution.

Heptachlor, heptachlor epoxide, and chlordane residues have also been found in food samples. Market basket samples for total diet studies were purchased from retail stores on a bi-monthly basis in five regions of the United States over a 6½ year period. Heptachlor epoxide was commonly found in the dairy, meat, fish and poultry components of the diet, with the residue levels ranging from trace (0.001 ppm) up to .03 ppm. The same surveys have indicated the presence of chlordane with first quarter 1974 levels being found at 0.01 to 0.3 ppm in significant percentages of cattle and poultry. The primary source of such residues in these products is probably the use of chlordane and heptachlor on feed crops like corn and alfalfa.

The most important aspect of the movement of heptachlor and chlordane in the environment is the presence of the metabolites of these pesticides in man. Human monitoring studies conducted in this country found concentrations of heptachlor epoxide in the adipose tissue in 96 percent of the 3451 hospital patients studied in 1970 (mean concentration: 0.08 ppm); 96 percent of the 3768 patients studied in 1971 (mean concentration: 0.08 ppm); and 93 percent of the 2854 patients studied in 1972 (mean concentration: 0.09 ppm). (Level of detection = 0.01 ppm). Oxychlordane residues were detected in the adipose tissue of 97 percent of 3339 patients sampled in 1971 (mean concentration: 0.10 ppm), and 97 percent of 2707 patients sampled in 1972 (mean concentration: 0.11 ppm). (Level of detection = 0.02 ppm). Residues of heptachlor epoxide in adipose tissues ranged as high as 2.68 ppm, while oxychlordane residues were as high as 1.61 ppm. Recent studies indicate that an additional chlordane metabolite, transnonachlor, may also be present in a very high percentage of humans.

Concentrations of heptachlor epoxide residues are found not only in adults, but in stillborn infants as well. The organs of 10 stillborn infants obtained in two Atlanta hospitals were found to contain an average of 0.54 ppm heptachlor epoxide. The highest levels were found in the heart, adrenal gland, and liver. The finding of residues in stillborn infants demonstrates that heptachlor epoxide is transferred from the mother to the infant across the placenta. In addition, 53 human milk samples collected in Philadelphia, and Center County, Pennsylvania, had an average concentration of heptachlor epoxide of 0.16 ppm (in milk fat) in a study reported in 1972. Three of the samples were in the 0.40 ppm to 0.49 ppm range.

These findings are disturbing since organisms that are exposed from the time of conception and then for the balance of their life are apt to be more responsive than those whose exposure begins after weaning. For this reason evidence that human fetuses are exposed across the placenta is considered especially significant even without quantitative evaluation. Similarly, levels in milk that may be the sole source of food for infants is of especial concern even though that level may not be continued after weaning. Quantification of the risk to man on the basis of a comparison between the levels of a carcinogen to which man is exposed and the levels which produced cancer in experimental animals is extremely difficult because of the number of factors which must be considered. In the case of heptachlor epoxide, experimental animals were dosed only by the oral route whereas man may be exposed by inhalation of air as well. The dosage to which animals are exposed are often in terms of concentrations in the feed (10 ppm and 0.5 ppm in experiments reported above). For a direct comparison of oral dosages, the concentration in feed (or man's food) must be multiplied by the volume of feed (or food) consumed per day to give the daily intake of the carcinogen. This must be further adjusted either for weight or size of the animal or man. Even such an adjustment is incomplete without some compensation for differences in metabolic rates. Both length of exposure (probably in terms of percentage of normal life span) and the age at which exposure is initiated must be considered. Additionally, an assumption must be made about the relative sensitivities of the experimental animals and man to the carcinogen in question. In the absence of data concerning the carcinogenicity of heptachlor epoxide to man, we must assume that the relative sensitivity of man to this effect is comparable or possibly greater than that of the experimental animals unless there is convincing evidence otherwise.

Thus even though it is impossible, because of all of the unquantified factors discussed above, to assign a numerical probability to the risk that heptachlor expoxide may produce cancer in humans, some generalized conclusions are possible. The presented evidence of measurable quantities entering man's body and further being transferred to fetuses in the uterus, indicates that humans are exposed to heptachlor epoxide from the moment of conception on throughout life. This is sufficient basis for grave concern for the possibility that humans, like the experimental mice and rats, may react to such exposure by producing malignant tumors.

VII. ECONOMIC IMPACTS OF CANCELLATION

On the basis of present information, national macroeconomic effects from the cancellation of chlordane and heptachlor are estimated to be negligible. Overall national production, cost and price effects will be minor for all uses. However, some microeconomic effects in specific regional and local areas may occur for corn, particularly on land subject to black cutworm infestation. Some microeconomic effects are possible for citrus and strawberry uses. Certain specialty crops may also be impacted but this will need to be assessed in the hearing. For all remaining uses including hay and forage, tobacco, peanuts, vegetables, livestock, soybeans, cotton, potatoes, grapes and other fruits and vegetables, there is no indication of significant macro- or micro-economic impacts or dislocations.

VIII. BALANCE OF RISKS AND BENEFITS

For the purposes of the following discussion, findings with regard to the risk of heptachlor must apply to registered chlordane products since chlordane as registered and used always includes heptachlor in substantial amounts.

A discussion of the risks associated with a pesticide under question as posing environmental or human health concerns must be based upon assessment of two interrelated factors: the toxicological characteristics of the compound, and the availability of the compound in environmental compartments which leads to exposure of man or of other organisms. Neither factor taken alone is sufficient to determine or estimate total risk. Evidence concerning risk will, then, be summarized in two parts: First, the effects of chlordane and heptachlor on man or other organisms; and second the levels of exposure which have been found to occur as a consequence of the use of these two products.

Concerning toxicity, heptachlor epoxide has been demonstrated to be carcinogenic in two species of laboratory animals: mice and rats at levels as low as 10 ppm and 0.5 ppm respectively. In the rat studies, several organs in addition to the liver, including the endocrine glands, showed increases in tumors. Both heptachlor and chlordane have significant toxicity for various species of wildlife, although it is difficult to determine what impact these toxicities have on species populations, as opposed to individual fish or wildlife or specific local populations.

With respect to exposure, available evidence indicates that both chlordane and heptachlor or their metabolites are present in water, dairy products, and other foods. Man's exposure to these compounds at significant levels is demonstrated by residues present in human milk, and the distribution of the compounds throughout the organs of stillborn fetuses. Analysis of autopsy and biopsy samples shows chlordane, heptachlor, and/or their metabolites at significant levels in human adipose tissue, further indicating intake and bioconcentration by man.

Available evidence of the costs of discontinuing the use of heptachlor and chlordane can be summarized as follows: Economic costs of pest control may rise but it is expected that the use of alternative means of pest control will allow continued control at costs which indicate no significant adverse macroeconomic effects. In certain geographical areas or for certain crops, microeconomic dislocations at the farm or county level might occur. The extent of this impact, if any, will need to be assessed further in the hearings.

IX. CONCLUSION

Weighing the risks presented by the continued use of heptachlor and chlordane against their benefits, it appears that they pose an unreasonable risk to man. Although these risks require further definition, a notice of intent to cancel these products should be issued in order that both the risks and the benefits may be more fully developed through the public hearing process. Public hearings should allow all pertinent evidence to be brought forth and examined so that a fully informed, indepth analysis of risks and benefits may be made, and appropriate remedies fashioned. Remedies to be considered at the hearings should include strengthening use restrictions, should any be appropriate, as well as removal of these products from the market for some or all uses.

Because heptachlor and chlordane have a very large number of uses, the Agency reserves the opportunity to present evidence on any registered use affected by this order regardless of whether or not a hearing has been requested on that use, or whether or not such use is to be actively defended in the hearings.

The only exceptions to the notice of intent to cancel are the use of chlordane and heptachlor for subsurface ground insertions for termite control and for the dipping of nonfood plants. These uses achieve the desired control of insects without apparent unreasonable environmental contamination.

A draft environmental impact statement concerning this intent to cancel certain products containing heptachlor and chlordane is being prepared and will be available in approximately 60 days.

An Order concerning intrastate products containing heptachlor and chlordane is also being issued today.

Dated: November 18, 1974.

RUSSELL E. TRAIN,
Administrator.

[FR Doc.74-27518 Filed 11-28-74;8:48 am]

APPENDIX G

FEDERAL REGISTER NOTICE OF EPA ADMINISTRATOR'S INTENT TO SUSPEND CERTAIN REGISTERED USES OF CHLORDANE AND HEPTACHLOR

August 15, 1975

[FRL 417-1]

REGISTRATIONS OF PESTICIDES CONTAINING HEPTACHLOR OR CHLORDANE

Intent To Suspend Findings of Imminent Hazard

On November 18, 1974, I determined that the continued registration and use of pesticides containing heptachlor or chlordane posed a substantial question of safety and accordingly I issued "Notice of Intent to Cancel" such registrations pursuant to Section 6(b) of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended ("FIFRA"). New evidence has recently come to my attention which confirms and heightens the human cancer hazard posed by these pesticides. In addition it is now apparent that the ongoing cancellation proceedings would not be concluded in time to avert substantial additions of these persistent and ubiquitous compounds to already serious human and environmental burdens. In view of these recent developments which are discussed in greater detail below, I find that continued use of these pesticides during the time required for completion of the cancellation proceedings would be likely to result in unreasonable adverse effects on the environment. Accordingly, pursuant to FIFRA Section 6(c), I hereby issue notice of intent to suspend the registrations and prohibit the production for use of all pesticides containing heptachlor or chlordane other than those registrations exempted from the heptachlor/chlordane cancellation order. This suspension order shall become effective within five days of the receipt by affected registrants unless the registrants request an expedited hearing pursuant to FIFRA Section 6(c)(2) and in accordance with the provisions of 40 C.F.R. Section 164.121. The suspension hearing, if requested, shall take no longer than 40 hearing days from the commencement of the hearing, unless for good cause shown and upon recommendation of the presiding officer I extend the hearing time for not more than 10 additional hearing days.

The Cancellation Notice. The Notice of Intent To Cancel Registrations Of Certain Pesticide Products Containing Heptachlor Or Chlordane[1] was based upon the following:

data from human monitoring studies showing that more than 90% of the American people have residues of heptachlor epoxide and oxychlordane in their tissues;

data from human stillborn infant monitoring studies showing that heptachlor epoxide is transferred from mother to child across the placenta;

data from human milk monitoring studies showing that heptachlor epoxide is present in a substantial percentage of mothers' milk at levels ranging from trace amounts to 0.49 ppm;

data from human food monitoring studies showing that heptachlor epoxide is commonly found in the dairy, meat, fish and poultry components of the human diet at levels ranging from 0.001 to 0.03 ppm;

data from two test animal feeding studies showing that heptachlor and heptachlor epoxide caused cancer and the conclusion of the Carcinogenicity Panel of the HEW Secretary's Commission on Pesticides and their Relationship to Environmental Health that heptachlor epoxide was "positive for tumor induction"; and

data from nationwide residue monitoring studies indicating that heptachlor and chlordane are highly persistent, lipid soluble and ubiquitous.

Additional Cancer Evidence. Since the issuance of the cancellation notice in November, 1974, I have received additional evidence which confirms the cancer hazard posed by these chemicals.

First, additional expert pathologists have reviewed both of the 1959 and the 1965 test animal feeding studies referred to in the cancellation notice. Their reviews support and strengthen the finding that these two studies demonstrate the carcinogenicity of heptachlor and heptachlor epoxide.

Second, new evidence of the results of additional 1973 test animal feeding studies conducted for Velsicol Chemical Corporation with heptachlor and chlordane have been submitted to EPA.[2] The heptachlor study reported a statistically significant increase of hyperplastic nodules in exposed animals with relatively few carcinomas. This result is itself indicative of carcinogenic action. In recent months, independent review of selected heptachlor and heptachlor epoxide tissue slides from this study by EPA consultant pathologists found substantial numbers of carcinomas. The analysis of the EPA consultant pathologist who reviewed all of the more than 650 heptachlor and heptachlor epoxide tissue slides found statistically significant increases in carcinomas of exposed animals over controls. In addition, a review of the animal tissues by pathologists consulted by Velsicol which has recently been brought to my attention found that substantial numbers of lesions originally reported as hyperplastic nodules were carcinomas.

The chlordane study reported a statistically significant increase in hyperplastic nodules and a substantial increase in carcinomas. Independent statistical analysis by EPA consultants demonstrates that at one feeding level (25 ppm) male mice exhibited statistically significant increases in carcinomas. Independent review of selected slides by the EPA consultant pathologists also found substantial numbers of carcinomas. A review of virtually all of the chlordane test slides by an EPA consultant pathologist demonstrated statistically significant increases in carcinomas of exposed animals over controls in both sexes at two feeding levels (25 ppm and 50 ppm). Selected tissue review by the Velsicol consultants also found substantial numbers of carcinomas in animals exposed to chlordane.[3]

Third, human adipose tissue studies for FY 1973 have now been completed and confirm the residues discovered in prior years samplings, finding heptachlor epoxide in 97.71% and oxychlordane in 98.35% of the people sampled. Similarly, whereas the cancellation notice referred to a 1972 human milk study which found heptachlor epoxide residues in mothers' milk, new evidence from an EPA survey shows heptachlor epoxide residues in 35.09% and oxychlordane residues in 45.61% of human milk samples taken.

Fourth, it is now anticipated that the cancellation hearing could require as much as 18 months of additional litigation before a final decision could be reached. During that period more than 38 million pounds of technical heptachlor and chlordane are likely to be released into the environment through uses contested in the cancellation proceeding.

In view of the mounting evidence that these compounds cause cancer and in view of the large quantity which will be added to human and environmental burdens in the interim, I find that the continued registration of the contested uses of heptachlor and chlordane pending completion of the cancellation proceeding poses an unreasonable risk to the American people and thus constitutes an "imminent hazard" under Sections 6(c) and 2(e) of FIFRA.

Legal Authority. Section 6(b) of FIFRA authorizes the Administrator to issue notice of intent to cancel if it appears to him "that a pesticide or its labeling . . . does not comply with the provisions of this Act or, when used in accordance with widespread and commonly recognized practice, generally causes unreasonable adverse effects on the environment . . . ." The phrase "unreasonable adverse effects on the environment" is defined by FIFRA Section 2(bb) to mean "any unreasonable risk to man or the environment, taking into account the economic, social and environmental costs and benefits of the use of any pesticide."

In accordance with FIFRA section 6(c), where the Administrator finds that "action is necessary to prevent an imminent hazard during the time required for cancellation . . ." he may by order suspend the registration after providing an opportunity for an expedited hearing on the question of "whether an imminent hazard exists." The term "imminent hazard" is defined by FIFRA section 2(l) to mean a "situation which exists when the continued use of a pesticide during the time required for cancellation proceeding would be likely to result in unreasonable adverse effects on the environment or will involve unreasonable hazard to the survival of a species declared endangered by the Secretary of Interior under Public Law 91-135."

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[1] 39 Fed. Reg. 41298 (November 26, 1974). For purposes of clarification, the result of a final order of suspension will be to prohibit the manufacture of heptachlor/chlordane pending completion of the cancellation proceedings for any registered use except for subsurface ground insertion for termite control and the dipping of roots and tops of non-food plants. The permitted termite use was clarified by notice published on July 21, 1975 (40 Fed. Reg. 30522).

[2] Technical chlordane contains approximately 7% heptachlor and technical heptachlor contains approximately 20% of the gamma isomer of chlordane.

[3] A preliminary report of the analysis of test animal feeding studies conducted for the National Cancer Institute further indicates that carcinogenicity of heptachlor and chlordane. Since the final report of the analysis of this study has not been issued, however, my decision to suspend heptachlor and chlordane registrations does not rely on this study.

The courts have repeatedly "cautioned that the term 'imminent hazard' is not limited to a concept of crisis: 'It is enough if there is *substantial likelihood* that serious harm will be experienced during the year or two required in any realistic projection of the administrative [cancellation] process.' " *Environmental Defense Fund, Inc. v. Environmental Protection Agency*, 510 F. 2d 1292, 1297 (D.C. Cir. 1975) (emphasis in original), quoting from *Environmental Defense Fund, Inc. v. Environmental Protection Agency*, 465 F. 2d 528, 540 (D.C. Cir. 1972). Of course, as in the cancellation proceeding, the Administrator does not have the burden of proving that a pesticide is unsafe since the statute and case law place "[t]he burden of establishing the safety of a product requisite for compliance with the labeling requirements . . . at all times on the applicant and registrant." *EDF v. EPA*, 510 F. 2d at 1297; *EDF v. EPA*, 465 F. 2d at 540.

The courts have consistently held that "the function of the suspension decision is to make a preliminary assessment of evidence and probabilities, not an ultimate resolution of difficult issues. We cannot accept the proposition . . . that the Administrator's findings [are] insufficient because controverted by respectable scientific authority. It [is] enough that the administrative record contain respectable scientific authority supporting the Administrator." *EDF v. EPA*, 510 F. 2d at 1298; *EDF v. EPA*, 465 F. 2d at 537.

As I have repeatedly stated,[6] after extensive EPA experience in evaluating the cancer hazard of pesticides, we do not begin our evaluation of the cancer threat of heptachlor/chlordane in a vacuum. In my prior orders relating to DDT and Aldrin/Dieldrin, and in the Preamble to the FIFRA registration regulations, I have set forth the basis for evaluating the carcinogenicity of pesticides which I am applying in evaluating the cancer hazard posed by the use of heptachlor and chlordane for purposes of this suspension notice and which shall be applied to evaluate that hazard in an expedited suspension hearing, if a hearing is requested. This basis for evaluation can be summarized as follows:

The use of animal test data to evaluate human cancer risks has been widely accepted by the scientific community and by public policy-making agencies. Such data are particularly appropriate because the relatively short life span of test animals allows for testing for the entire latency period for tumor development and because of our relatively well-developed understanding of the pathological development of tumors in mice and rats. When compared to the millions of people who may be exposed to a pesticide, the number of animals used in tests to evaluate oncogenicity is extremely small. The variability of human response to carcinogens is generally greater than that of the test animals. Epidemiological cancer data are desirable, but because of the long latency period of tumor induction in humans, because of frequently encountered widespread contamination which makes it impossible to establish an uncontaminated control group and because of the obvious ethical and legal problems associated with conducting cancer research on humans, reliable epidemiological data are rarely available. Accordingly a positive oncogenic effect in test animals is sufficient to characterize a pesticide as posing a cancer risk to man. By the same reasoning, negative results from oncogenic animal tests have only limited significance. The number and sensitivity of the test animals as compared to the general human population are the principal reasons for this limited utility. Because of these inherent limitations of animal testing a pesticide that induces tumors in experimental animals at any dose level must be considered to be a carcinogen. As noted above, negative results are of limited value since they do not rule out the possibility that the chemical will induce tumors in test animals if, for example, the number of exposed animals or the length of exposure were increased. Although a no-effect level may theoretically exist for carcinogens, as yet there is no scientific basis for establishing such a level. Thus, human exposure to a carcinogen at levels below those which induced positive effects must be considered to present a cancer risk. Finally, although the distinction between "benign" and "malignant" tumors is of primary importance to the individual, it is not a meaningful distinction in determining the cancer hazard to man on the basis of tests conducted on laboratory animals. Given the increasing evidence that many "benign" tumors can develop into cancers, for purposes of determining whether a pesticide poses a cancer hazard to man on the basis of laboratory experiments, the terms "benign" and "malignant" should be considered synonymous.

With respect to the benefits of continued use of a pesticide subject to a notice of intent to suspend, the courts have ruled that because of the expedited and provisional nature of the suspension process it is not necessary to explore all of the available information on alternative pest control methods to the same degree as in a cancellation proceeding. Although consideration of such alternative methods will be undertaken in the suspension process, the responsibility to demonstrate that the benefits of continued registration during the cancellation proceeding outweigh the risks is upon the proponents of continued registration.

Some uncertainty has arisen concerning the Agency's burden of going forward with evidence of alternative means of pest control in its affirmative case. In the Opinion of the Administrator with respect to *Stevens Industries, Inc.* (37 F.R. 13369) reference was made to the burden of the respondent to show "the availability of a registered chemical or other means of control which this Agency's Pesticides Office is prepared to recommend as a substitute. . . ." 37 F.R. 13372. It was not intended by that statement, nor does the applicable law require, that the Agency staff—as part of its affirmative case—offer such an Agency "recommendation" or that it provide evidence that alternatives which are registered for the uses in question are actually obtainable, efficacious or available at reasonable prices. It is sufficient for purposes of its presentation that the Agency staff present evidence that alternatives are registered for the uses in question. This may be accomplished by an affidavit by the appropriate official certifying that the substances listed therein are registered for the uses indicated. The burden of demonstrating that any alternatives established by respondent in this fashion are not actually obtainable, are not efficacious or are not available at reasonable prices remains on the proponents of contained registration of the pesticides under review in a cancellation or suspension proceeding.

Finally, the Court of Appeals has held that the Agency is under a heavy burden to justify any decision that the benefits outweigh the risks with respect to a chemical known to produce cancer in experimental animals.

Findings of Imminent Hazard. On the basis of the data before me at the time of my November, 1974 cancellation notice and the additional data which has been brought to my attention in the intervening nine months, pursuant to FIFRA Section 6(c)(1) I make the following findings as to imminent hazard which shall constitute the issues to be adjudicated at a suspension hearing, if such a hearing is requested:

1. Virtually every person in the United States has residues of heptachlor epoxide and oxychlordane—the principal metabolites of heptachlor and chlordane—in his body tissues. Analysis of human tissue samples by the EPA National Human Monitoring Program shows that during FY 1970, 1971, 1972 and 1973 heptachlor epoxide was present in human adipose tissue at quantifiable levels in 90.29% to 97.71% of all the people tested. During each of these years the arithmetic mean of the concentration of heptachlor epoxide in human

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[6] *See* Opinion of the Administrator, Environmental Protection Agency, on the Suspension of Aldrin-Dieldrin, 39 Fed. Reg. 37265 (October 18, 1974); State of Louisiana Request for Emergency Use of DDT on Cotton, Statement of Reasons for Denial and Supplemental Statement of Reasons for Denial, 40 Fed. Reg. 1034, 15040 (April 8, 1975); Preamble to Subpart A—Registration, Reregistration and Classification Procedures, 40 Fed. Reg. 28242, 28263 (July 3, 1975).

tissues ranged from 0.12 to 0.17 ppm and the highest concentration was 10.62 ppm. Oxychlordane, which was first included in the EPA Human Monitoring Program in FY 71, was present in FY 1972 and 1973 human adipose tissue samples at quantifiable levels in 92.33% to 98.35% of all the people tested. During each of these years the arithmetic mean of the concentration of oxychlordane in human tissues was 0.15 ppm and the highest concentration was 1.87 ppm.

2. Data from human stillborn monitoring studies show that heptachlor epoxide crosses the placental barrier and enters the human fetus. The stillborn study found that heptachlor epoxide residues were present in 4 out of 10 adipose tissue samples in amounts ranging from 0.07 to 0.51 ppm. In addition, heptachlor epoxide residues were detected in the brain, adrenals, heart, lungs, liver, kidney and spleen. The concentrations ranged as high as 1.56 ppm in the heart and 1.67 ppm in the liver. Of 30 live term babies examined, 90% had heptachlor epoxide residues in their cord blood in amounts ranging from 0.0002 to 0.0043 ppm.

3. Recently obtained data demonstrates that 35.09% of human mothers' milk sampled contains quantifiable residues of heptachlor epoxide and that 45.16% of mothers' milk sampled contains quantifiable residues of oxychlordane.

4. For the most recent reporting period of FY 1974, the Food and Drug Administration, in its market basket survey, reports that measurable amounts of heptachlor, heptachlor epoxide or chlordane were found in composite samples of 73 percent of all dairy products and 77 percent of all meat, fish, and poultry samples. Residues of these chemicals have consistently been detected throughout the preceding ten years in dairy products and meat, fish and poultry. During the ten fiscal years from 1965 to 1974, residues of these three chemicals have been detected in all of the twelve food composite categories.

5. Approximately 50% of the heptachlor/chlordane used under contested registrations is applied for home, lawn and garden purposes as well as commercial turf. These uses accounted for more than 7,500,000 pounds of technical chlordane in 1974. Use of this chemical under these conditions presents special problems of human exposure. These applications are in and around the home and thus are generally in much closer proximity to the general population than agricultural uses. Similarly, many of these applications are carried out by individual homeowners who may expose themselves, their family members and their neighbors by direct contact with the skin, by inhalation, by contamination of clothing as well as by ingestion. In addition, many of these uses around the home appear to result in residues in urban and suburban soils. Soil monitoring studies of urban and suburban areas show that residues of chlordane were detected in the soils of all 37 cities sampled between fiscal years 1969 and 1974. For many cities chlordane was detected in approximately 30% to 40% of the samples. Residues of heptachlor epoxide were detected in the soils of 28 of the cities sampled and heptachlor residues were detected in the soils of 13 of the cities sampled. In several cities heptachlor epoxide residues were present in 10% to 20% of the soil samples. Common experience demonstrates that contaminated soil and turf around the home may present special hazards to family members through transport by pets and direct contact—this hazard would appear to be particularly alarming in the case of young children.

6. Heptachlor epoxide has been found to produce significant increases in tumors in a 1965 mouse experiment conducted by FDA. Based upon data from this experiment the Carcinogenicity Panel of HEW Secretary's Commission on Pesticides and Their Relationship to Environment Health found heptachlor epoxide to be "positive for tumor induction." Independent review of this experiment by EPA consultants has shown that there was a statistically significant increase in carcinomas in animals fed both heptachlor and heptachlor epoxide. Statistical review of a 1959 experiment testing heptachlor epoxide in rats has shown that this compound also produced significant increases in tumors. Histological review by EPA consultants has shown that the treated animals in this experiment had substantial increases in carcinomas.

As noted above, recent data from mouse experiments conducted for Velsicol Chemical Corporation have shown that heptachlor and heptachlor epoxide significantly increased the incidence of hyperplastic nodules in treated mice. Although this finding itself is indicative of carcinogenesis, review of these data by pathology consultants for both Velsicol and EPA has shown that substantial numbers of these lesions were carcinomas. These same experiments have shown a significant increase in tumors and hyperplastic nodules for animals fed chlordane. Review of the chlordane data by consultants for Velsicol and EPA has revealed that substantial numbers of lesions originally diagnosed as nodules were carcinomas.

7. Based upon estimated production figures supplied by Velsicol Chemical Corporation for the last 6 months of 1975, a total of more than 38 million pounds of heptachlor and chlordane intended for domestic use under contested registrations are likely to be produced during the 18 months required to conclude the cancellation hearings. The 18 month production of heptachlor for contested uses is estimated to be almost 10 million pounds while chlordane production for contested uses is estimated to exceed 28 million pounds.

8. Finally, although heptachlor/chlordane are widely used as insecticides, the major agricultural use of heptachlor and chlordane is on corn, with over 70% of the agricultural use being devoted to use on corn. According to statistics of the United States Department of Agriculture, the maximum estimated loss to corn production from cancellation of heptachlor/chlordane and aldrin/dieldrin taking into account numerous registered alternative pesticides would be approximately 0.4% of the nation's 1973 total corn production. The USDA forecast of a bumper corn harvest for 1975 demonstrates that even for the current crop year total losses would not exceed approximately 0.4%. Although a few individual corn growers may experience some losses in production if heptachlor/chlordane are not available these potential losses should not be widespread and in view of the serious risks certainly do not justify continued use.

Additional agricultural uses of heptachlor/chlordane are small and varied. Alternative pesticides are registered for almost all of these uses and in the few instances where no alternative is presently registered, there has been no indication that serious crop losses would occur pending completion of the cancellation process. Similarly, although we are also sensitive to the needs of homeowners who use chlordane, there is a wide selection of registered alternative pesticides to replace the numerous uses of chlordane in and around the home.

* * * * *

Although we cannot determine precisely the magnitude of the human cancer risk as a result of the past and continuing exposure to heptachlor and chlordane, I have found that these compounds cause cancer in laboratory animals and that laboratory tests are reliable indications of the human cancer hazard. In addition, although any single component of human exposure—such as intake through poultry—may not appear to be significant, it alone poses a cancer hazard to certain of the more susceptible individuals and together with the several other components of human exposure presents a serious human cancer threat. This threat is made even more alarming by evidence that human exposure begins in the mother's womb and continues without interruption throughout life. In addition, because these chemicals are ubiquitous, the major souces of human exposure are largely unavoidable by individual action.

I have invoked the "Special Rule" provision of section 15(b)(2) permitting continued use of those existing stocks of EPA registered pesticides containing heptachlor or chlordane which have been formulated as of the date of this notice. It seems clear considering the use patterns of heptachlor and chlordane that there would be no stocks realistically retrievable following a suspension notice. The major use, home, lawn and garden, which constitutes more than 40% of the uses covered by this notice, is a nationwide use made available to the homeowner through a complex distribution network. It would not be feasible to monitor such a network and to retrieve such stocks. Any such stocks are probably already in the hands of homeowners and other users or local retail stores and their immediate distributors. In addition, use under corn, which constitutes more than 35% of the contested uses, has already occurred and thus there should not be substantial existing stocks for that purpose.

Dated: July 29, 1975.

RUSSELL E. TRAIN,
Administrator.

[FR Doc.75-21466 Filed 8-14-75;8:45 am]

EPA ACTIONS TO CANCEL AND SUSPEND USES OF CHLORDANE AND HEPTACHLOR AS PESTICIDES: ECONOMIC TESTIMONY PRESENTED BY EPA AT CHLORDANE/HEPTACHLOR SUSPENSION HEARING

PART II

September 1975

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STATEMENT FOR TESTIMONY AT CHLORDANE/HEPTACHLOR SUSPENSION HEARING

September, 1975
Requested by the Environmental Protection Agency

Dr. Arnold L. Aspelin
Chief, Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs, EPA
Washington, D.C. 20460

CERTIFICATE OF SERVICE

I certify that I have this day supervised the filing of one copy of the attached "Statement of Arnold L. Aspelin to the Hearing Clerk, U. S. Environmental Protection Agency, and I have also supervised hand delivery of copies of the attached to:

Robert Weinberg, Esq.
Williams, Connolly & Califano
839 17th Street, N. W.
Washington, D. C.

Robert L. Ackerly, Esq.
Sellers, Conner and Cuneo
1625 K Street, N. W.
Washington, D. C. 20006

Alfred R. Nolting, Esq.
Counsel for the Secretary of
Agriculture
Room 2042-A, South Building
14th & Independence Avenue, S. W.
Washington, D. C. 20250

Jacqueline M. Warren, Esq.
Environmental Defense Fund
1525 Eighteenth Street, N. W.
Washington, D. C. 20036

Lee Charles Schroer

Dated: September 12, 1975

GENERAL USE PATTERNS OF CHLORDANE AND HEPTACHLOR

Chlordane

Chlordane is a commonly used insecticide in agriculture, industry, and the home, lawn and garden. About 21 million pounds were used in the United States during 1974.

Data provided by Velsicol Chemical Corporation (Exhibit A) indicate the following approximate breakdown for chlordane use in 1973 and 1974:

Use	Million Pounds		Percent	
	1973	1974	1973	1974
Corn	1.94	4.32	10.8	20.4
Potatoes	0.98	1.11	5.5	5.2
Other vegetables	0.06	0.07	0.3	0.3
Home lawn and garden	5.77	6.33	32.1	29.9
Turf	1.14	1.25	6.3	5.9
Strawberries	0.15	0.17	0.8	0.8
Tomatoes	0.30	0.33	1.7	1.6
Ornamentals	0.23	0.25	1.3	1.2
PCO	7.41	7.34	41.2	34.7
Total	17.98	21.18	100.0	100.0

The proposed suspension would cover about two-thirds of total chlordane use (65.3 percent in 1974), not counting some pest control operator (PCO) use which might also be included.

Chlordane is a leading insecticide in the United States, although it accounts for less than 6% of total U.S. insecticide use. It is widely used in the home and garden and industrial/commercial use areas, where in 1972 it ranked number 1 in each use with about 23% and 30% of U.S. use in those respective categories as indicated below:

Use	Amount Used: All insecticides, Million Pounds	Amount Used: Chlordane, Million Pounds	Amount Used: Chlordane, Percent	Chlordane rank
Agriculture	218.9	3.0	1.4	9
Home and garden	21.8	5.0	22.9	1 (tie)
Governmental	7.0	0.5	7.1	4
Industrial/commercial	21.5	6.5	30.2	1
Overall	269.2	15.0	5.5	5

(Based on MRI/RvR report for CEQ and EPA, EPA 540/1-74-001, 1974 -- Exhibit B).

Comparable data on the ranking and relative importance of chlordane in major insecticide use categories are not available for a more recent year than 1972. Patterns are not likely to be vastly different now.

According to USDA surveys, crop uses account for 70% to 85% of agricultural use of chlordane in the United States and protection of corn from attack by soil insects accounts for more than one half of agricultural use (Exhibits C and D). There is no trend shown in the USDA surveys as to changes in percentage breakdown among general types of agricultural uses. However, there appears to be a trend toward increased use of chlordane in agriculture generally, inasmuch as the 1971 use level of nearly 1.9 million pounds was more than three times that for 1964 and 1966, and more recent estimates by Velsicol indicate that approximately 6 million pounds were used in agriculture during 1974. The suspension of aldrin/dieldrin will increase demand for chlordane, along with other substitutes, leading to increased production and use of chlordane beginning in 1975 or 1976.

Numerous other crop uses have been identified in USDA surveys (Exhibit D). The extent of these uses varies considerably according to available estimates.

Government agencies use significant amounts of chlordane. Annual use of chlordane has been estimated at 0.5 million pounds for Federal, state and municipal agencies (MRI/RvR report for CEQ and EPA, EPA 540/1-74-001, 1974 - Exhibit B).

Heptachlor

Heptachlor is used in a much smaller volume than chlordane (about 2 million pounds in 1974 compared with 21 million for chlordane) and is used in fewer types of applications. Data provided by Velsicol Chemical Corporation (Exhibit A) indicate the following approximate breakdown for use in 1973 and 1974:

Use	Million Pounds 1973	Million Pounds 1974	Percent 1973	Percent 1974
Corn	1.13	1.19	57.4	58.0
Seed dressing	0.19	0.27	9.6	13.2
PCO	0.61	0.55	31.0	26.8
Fire ants, misc.	0.032	0.04	1.6	2.0
Total	1.97 *	2.05	100.0 *	100.0

The "Fire ant, misc." category of use in the above table includes use on pineapple, which is estimated at about 10,000 pounds annually (Exhibit A). Velsicol Chemical Corporation also indicates that there may be several thousand pounds of heptachlor used on citrus to replace suspended aldrin use in Florida.

About three-fourths of heptachlor is devoted to agricultural use, and that is largely for corn soil treatments (Exhibit A). Corn accounted for 91 percent of agricultural heptachlor use in 1971, according to USDA's survey (Exhibits E and F). The remainder was divided among several other crop uses (e.g., alfalfa, other hay and pasture and vegetables). Heptachlor is not used in connection with livestock production as is chlordane (Exhibit E). Agricultural use

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*Do not add because of rounding

of heptachlor is largely in the Corn Belt states, with some use in the Lake States and the Northern Plains, (USDA/ERS, Agricultural Economic Report No. 252).

Heptachlor, with agricultural use of about 1.2 million pounds in the early 1970's, equals about 0.5% of U.S. agricultural use of insecticides (more than 200 million pounds as of 1972). The PCO use estimate for 1974 of more than 550,000 pounds (Exhibit A) equals less than 3% of U.S. industrial/commercial use (approximately 21.5 million pounds in 1972).

ECONOMIC IMPACT OF SUSPENDING CHLORDANE/HEPTACHLOR USE ON FIELD CORN

This section will consider the impact of the proposed suspension of chlordane/heptachlor use on field corn as follows:

1. Impacts during the year 1976 assuming the use of existing stocks as of July 29, 1975, would be authorized under a suspension.
2. Impacts during the first five years of suspended use on a projected typical-year basis, and on a worst-case basis, focus 1977.

Chlordane/Heptachlor Use Patterns

Corn is subject to attack by a wide variety of insects including corn rootworms, wireworms, and cutworms for which chlordane/heptachlor has often been recommended in the past. Chlordane and/or heptachlor have EPA registrations for use against these pests (Exhibit G) and a number of other lesser economic corn pests. Chlordane and heptachlor are not generally recommended for use against rootworms because resistance has developed. These chemicals are generally recommended by entomologists in the states for use against wireworms and cutworms (Exhibit G).

Chlordane and heptachlor together are used on about 2.6 million acres of corn in the U.S. as of 1975 (3.5% of total corn acreage). They are used on about 27,000 farms equalling about 3% of commercial corn farms in the United States. A detailed summary of the use of chlordane, heptachlor and other insecticides used on corn is presented in Exhibit H for 1973 and 1974 on the average and for 1975 for the U.S. by state for the principal corn states. A review of these data indicates the following characteristics:

1. Chlordane is used on about 1.2 million acres of corn equalling 1.6% of U.S. corn acreage and on about 12,000 farms equalling 1.3% of U.S. commercial corn farms as of 1975.
2. Heptachlor is used on about 1.4 million acres of corn equalling 1.9% of U.S. corn acreage and on about 15,500 farms equalling 1.7% of U.S. commercial corn farms.
3. With suspension of aldrin, its use has declined from 9.6% of U.S. commercial corn acreage in 1973/74 to 3.3% in 1975. Chlordane use increased to some extent (from 1.3% to 1.6% of U.S. corn acreage in 1975) while heptachlor use increased somewhat more sharply, from 1.2% to 1.9% of U.S. corn acreage.
4. Total acreage of corn treated with insecticides in the United States declined from 27.9 million in 1973/74 to 26.2 million in 1975 even though commercial corn acreage in the U.S. increased nearly 3 million acres. This decline in insecticide use may be associated with the aldrin suspension as aldrin use has declined from near 7 million acres in 1973/74 to near 2.5 million acres in 1975.
5. Two-thirds of the corn grown in the United States is not treated with any insecticide including both soil and foliar applications.
6. Most corn farms do not use insecticides of any type in the production of corn (more than 75% in 1975).
7. Several organophosphate and carbamate alternatives to chlordane/heptachlor for control of corn soil insects are in widespread use in the United States as of 1975. Alternatives for rootworms and

wireworms are used much more frequently than for cutworms. Diazinon, the only registered pre-emergence alternative for cutworms, is used on only 0.4 percent of corn acreage and rescue baits are used on limited acreage.

8. The leading states in use of chlordane/heptachlor as of 1975 based on percentage of corn acreage treated with these chemicals were: Missouri, 12.1; Illinois, 6.6; Indiana, 6.2; Iowa, 4.2; Ohio, 3.4; and Minnesota, 0.8.
9. Aldrin was used quite heavily in several of the corn states in 1975 (in terms of the percentage of corn acreage treated): Missouri, 17.9%; Indiana, 7.9%; Ohio, 7.2%; Illinois, 5.0%; and Iowa, 3.3%.
10. Missouri is by far the heaviest user of organochlorines with 30% of commercial corn acreage so treated in 1975. The next ranking state was far below (Indiana with 14.1%).
11. The number of commercial corn farms in the United States dropped from nearly 970,000 in 1973/74 to slightly under 900,000 in 1975, even though total corn acreage increased by more than 2 million acres.
12. Farms using insecticides are larger acreage corn farms than nonusers. This is true of organochlorines as well as other insecticides. These generalizations are evident as the percent of U.S. corn acreage treated by users exceeds the percent of U.S. corn farms accounted for by users.
13. Corn insecticide expenditures totalled nearly $105.7 million in 1975, up considerably from $78.7 million in 1973/74. Average expenditure per treatment acre was $4.04 in 1975 compared with $2.82 per acre

in 1973/74. Organochlorine treatments are less expensive than organophosphate and carbamate insecticides (about $2.50 compared with $3.50 to $5.00 per acre for alternatives).

Dynamics of Cutworm Infestation and Control

Cutworms are the primary corn soil insect pest for which chlordane and heptachlor are recommended to maintain yields (Exhibit G). They are seldom recommended for rootworms. For wireworms, many alternatives are recommended. This section is a brief discussion of the nature of cutworm infestations and alternative controls.

Cutworm infestations in corn are highly variable from year to year. Since 1969 the number of farms reporting cutworms as a major problem has varied from 19,000 to 71,000 in the United States with an overall average of about 53,000 (Exhibit I). This equals about 2% to 8% of U.S. corn farms. The percentage of these farms treated for cutworms during that period ranged from 52% to 71% with an overall average of 61%. The number of farms treating during 1969 to 1975 averaged about 32,000 and ranged from 13,000 to 48,000 (Exhibit I).

The sporadic nature of cutworm infestations in corn is somewhat more pronounced at the state level as the range in the number of farms reporting problems and/or treating may vary by a factor as high as 7 as indicated in Exhibit I.

The extreme variability in cutworm infestations frustrates attempts to project economic thresholds for treatment. It is extremely difficult to determine in the Spring whether pre-plant treatment would be justified except in high risk fields which have a history of cutworm problems. Rescue bait and spray treatments must be depended upon when there has been no pre-plant treatment or pre-plant treatment has failed in the face of an outbreak.

The limited prospect for the availability of pre-plant controls for cutworm areas with the suspension of the major remaining organochlorines increases the need for improved scouting techniques during the critical relatively short period of time when corn is subject to cutworm damage after emergence from the soil. Scouting is useful even with pre-plant treatment because such treatments at times fail. Such scouting can be facilitated by programs promoted by the extension service, industry and other organizations leading to improved control of cutworms. Research currently in progress should facilitate improved determination of economic thresholds for pre-plant and rescue treatments (EPA Soil Arthropod Project, Grant No. R802547, Dr. Mahlon Fairchild, University of Missouri, Coordinator).

Rescue treatments for cutworms such as Sevin (carbaryl) and Dylox (trichlorfon) are in the same cost range as chlordane/heptachlor (Exhibit J). These rescue treatments are less expensive than broadcast aldrin or chlordane/heptachlor treatment by $1 to $2 per acre. Also, they are not applied unless needed, which lowers costs to the farmer. Scouting must be practiced in order to use rescue treatments effectively. Scouting costs should be nominal inasmuch as scouting can, in many cases, be accomplished at little added cost in connection with other field operations, such as cultivation and routine observation of growing crops.

Trained scouts working under a pest management project in Illinois in 1974 cost $0.55 per scouted acre for the season plus an additional $0.44 for computer and other support, bringing total costs to $0.99 per acre (Report of Illinois Custom Spray Operator Training School, 1975, pp. 33-38). It is not clear what costs would be if such programs reach full scale operation. They could be below costs in the current pilot program. The Illinois project is not intended to grow into an operating program where costs of scouting are borne by the extension service. They will need to be borne by the grower, according to present plans (Report of Illinoi Custom Spray Operator Training School, 1975, p. 38).

National Economic Effects of Suspension

This section of my testimony summarizes the national economic effects of the suspension on corn based on our recent studies on this matter together with a brief review of earlier studies by USDA.

Earlier USDA Studies

USDA economists have conducted separate analyses of the impacts of cancelling chlordane and heptachlor use on corn. The first of these studies to be done was on chlordane (Economic Impact of Discontinuing Farm Use of Chlordane, Report No. 231, August, 1972) which indicated that there would be no yield impact from withdrawal of chlordane in the absence of replacement by other organochlorines but that there would be some increase in cost on about 200 thousand acres of corn in the United States. These results must be updated as acreage treated with chlordane has increased greatly and insecticide treatment costs have changed since that study was conducted.

Another USDA study evaluated the impact of shifting to alternatives to haptachlor on 699 thousand acres for the year 1971 (Economic Impact of Discontinuing Farm Uses of Heptachlor Report No. ERS - 509, January, 1973). This study indicated an increase in cost of $1.55 per acre for rootworms and $1.73 per acre for other soil insects giving a total cost impact of $1.1 million dollars. A yield reduction was projected to cause a reduction in U.S. corn production of about 800,000 bushels equalling 0.014% of the U.S. total in 1971.

Another USDA study was conducted on cancelling uses of soil insecticides on corn in 1974 (Economic Impact of Discontinuing Aldrin Use in Corn Production, Report No. ERS - 557, by Herman Delvo, June, 1974). This study indicated that production of corn on acreage treated with aldrin in 1971 would decline in a range of 0 to 30 percent depending on whether or not alternatives were used and depending on which pest, rootworms, wireworms or cutworms infested the aldrin treated acreage. Corn production was projected to decline by 21.1 million bushels (0.4 percent) if no organochlorine alternatives were used and 55.1 million bushels (0.8 percent) if no alternative controls were used on the aldrin treated acreage in 1971. Taking into account market price effects and cost impacts, the farm corn sector would experience a net income increase of $12.5 million to $76.4 million, depending on whether alternatives were used. A more detailed discussion of the results of these studies is presented in Exhibit K.

Economic Impacts of Suspension During Five Year Period -- Focus 1977

The testimony in this section summarizes results of a linear programming analysis of the U.S. agricultural sector focusing on the impacts of the combined suspension of chlordane and heptachlor as well as aldrin for use on corn during a five year period, typical year basis. The year 1977 is selected for purposes of presenting results of the analysis of impacts from the suspension as representative of the first five years of such suspension. The approach is to evaluate impacts of the cancellation by comparing a base solution of economic conditions in the agricultural sector for the year 1977 and a solution with the suspension of the organochlorines with resulting impacts on acreage, production and costs for seven crops (irrigated and dryland) (barley, corn, cotton, soybeans, oats, sorghum, and wheat). The model allocates acreage to these crops in more than 120 regions in least-cost manner as operators employ land in the use which yields the greatest return. The evaluation of impacts is made by comparing solutions with and without organochlorines being available.

Two evaluations were made with the use of the linear programming model:

1. Typical case -- where estimates of yield loss are in line with average actual long-term benefits from use of organochlorines over a wide geographic area over a number of years.

2. Worst case -- where yield reductions due to use of alternatives or no control are far in excess of long-term averages, but could happen in a given year if a number of factors work against yields in an atypical fashion.

The rationale for development of these two sets of yield coefficients is presented in Exhibit L. The basic approach was to use Delvo's coefficients for the worst case analysis for a given year and to use adjusted coefficients for the typical case analysis. The adjustment was based on long-term yield benefits associated with organochlorine control of corn soil insects. Delvo's estimates of impact on yield were supplemented by an additional assumption that land infested with rootworms would generate 8% higher yields if alternatives to organochlorines were used. Delvo had assumed that no increase in yield would occur, although he recognized the possibility that yields could increase from the use of alternatives on rootworm infested land.

A more detailed discussion of the linear programming model used in this analysis is presented in Exhibit M.

A summary of economic effects on key parameters as a result of the suspension of chlordane/heptachlor use on corn is presented in Table 1 for the typical and worst case solutions of the linear program and model. The results for the typical case solution indicate the projected effects on acres of corn grown, total corn production, prices and other variables during the period 1975-1980 using 1977 as a typical representative year for that period. These results are those which could be expected on the average or in a typical year during a five year period, as compared to those also presented in the table which would be representative of an atypical worst case year only.

Although the same basic model was used to generate the results for both cases, it is inappropriate to assume that worst case impacts would occur on a regular basis. In that instance, worst case would imply moderate to heavy infestation conditions throughout all corn producing states, failure of alternatives to control wireworm and cutworm pests, all of which are not likely to happen simultaneously in a given year or regularly during a five year period. Accordingly, my judgment is that the typical case outcomes indicated in Table 1 are reflective of the future on the average, whereas we should be mindful that in an individual year the worst case outcome could occur.

The key results in the analysis in the typical-year case are a slight increase in U.S. corn production (200,000 bushels) which is statistically insignificant; and an increase in acreage required to produce corn to meet domestic and export demands equalling 88,000 acres (which is also statistically insignificant on a nationwide basis). The change in total cropland for the seven major crops in the model was also slight (36,000 acres). Price impacts were modes, ranging from -.17% for soybeans and -.16% for wheat to +.14% for corn, which are very nominal in terms of typical year to year variations. Corn prices often move as much as 25% in a year due to weather and normal market factors.

The typical case solution indicates a modest increase in returns to land (which is a proxy for profit to landowners growing the seven crops included in the model) ($3.1 million or 0.01%). However, the corn sector experienced a negative effect in returns to land equalling $-6.1 million or -0.47%.

Production expenses for the seven crops included in the model increased $6.4 million, about 0.06% nationally (from $10,004.5 million to $10,010.9 million).

Table 1 -- Impacts of suspension of chlordane and heptachlor on corn, other grain and cotton sectors, U.S. economy 1975-80, projected typical case and worst case estimates, focus 1977

Item	Unit	Typical case	Worst case
		Change due to suspension (suspension solution minus base solution)	
A. Corn production	1,000 bu. (Pct.)	200 (0.0035)	-36,910 (-0.7)
B. Acres of cropland in use			
Corn	1,000 acres	88.3	200
Barley	"	2.9	170
Cotton	"	0.6	80
Soybeans	"	-49.0	-400
Oats	"	- 8.8	250
Sorghum	"	0	400
Wheat	"	1.7	450
Total	"	35.7	1,160
C. Price of crop			
Corn	Pct.	.14	2.6
Barley	"	.13	1.5
Cotton	"	.02	0.8
Soybeans	"	- .17	-0.3
Oats	"	0	1.7
Sorghum	"	.14	2.5
Wheat	"	- .16	0.6
D. Grain transport cost			
Corn	$million	-1.20	3.74
Other	"	+0.46	2.62
Total	"	-0.74	6.36
E. Returns to land - change in dollars	$million		
Corn	"	- 6.10	-6.36
Barley	"	2.40	5.06
Cotton	"	0.06	5.95
Soybeans	"	- 0.71	38.90
Oats	"	2.33	6.88
Sorghum	"	- 0.06	11.06
Wheat	"	5.20	10.07
Total	"	3.12	+71.25
F. Returns to land - change in percent	Percent		
Corn	"	- 0.47	-0.6
Barley	"	1.20	6.1
Cotton	"	0.07	1.7
Soybeans	"	- 0.08	4.2
Oats	"	2.22	13.3
Sorghum	"	- 0.02	4.2
Wheat	"	0.39	1.9
Total	"	0.01	2.2

Source: EPA linear programming analysis

The suspension would have a slight negative effect on a proxy measure of net income to growers of the seven crops included in the model which was calculated for comparative purposes. Net income would drop $8.5 million, from $8.397 billion to $8.839 billion. While this is true, income to corn growers nationwide would remain about constant. These negative impacts on income occur in contrast with the "worst case" analysis which indicates a net reduction in corn production with the result that prices for the crop produced would rise, thus increasing net income to the corn sector generally as well as the remainder of the agricultural sectors included in the model. In this instance (worst case), production changes were more extreme touching off price increases which allowed producers to pass on the majority of impacts to final consumers.

Impacts on the consumer through reduced production in crops and higher prices are not significant in total for a typical case year. Very minor effects would occur on prices of meat, poultry, eggs, cereals and fiber (including cotton) as a result of the suspension under a typical case outcome. The major significance of the suspension is within agriculture itself, as quite significant cost impacts would occur in affected regions as well as local and regional adjustments in crop production

The national impacts under the worst case analysis contrast with the alternative primarily in that there is a reduction in the production of corn equalling nearly 37 million bushels (-0.7%) leading to significant increases in the price of corn (2.6%) and also in other crops. The effect is to increase returns to agriculture significantly under the worst case assumptions. Market effects are quite significant under worst case assumptions in contrast with the typical case where essentially there is no significant market effect. Alternatively, the prime effect in the typcial case is a balancing of increased production costs against higher prices with a corresponding minor impact on overall net returns.

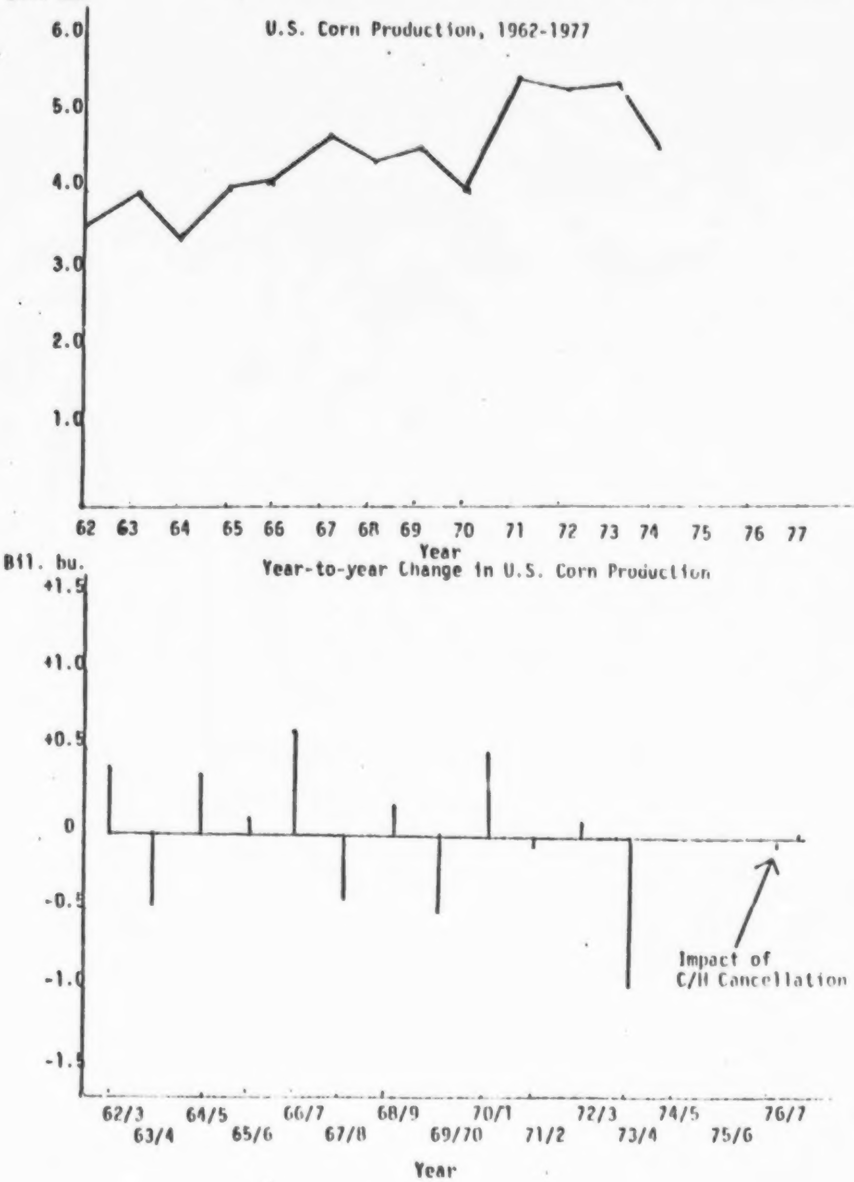
The impacts of the typical and worst case solutions on corn production as a result of a suspension can be brought into perspective by viewing them within the context of a year-to-year variation in corn production in the United States. Presented in Figure 1 are time series data on production of corn for the period 1962 to 1974 and year-to-year changes charted on a zero axis to more clearly illustrate the variability of changes. Since 1962, corn production has varied from a low of 3.5 billion bushels to more than 5.5 billion bushels, with year-to-year changes of as much as 500 million to 1 billion bushels. The worst case impact of -37 million bushels is nominal by comparison to year-to-year changes due to all factors impacting on production of corn in the United States.

The cost of transportation activities required to meet final demands decreased by $740,420 following restrictions in the use of organochlorines in the typical case. Corn transportation cost fell by $1,203,000 and was partially offset by an increase in required transportation of soybeans valued at $631,000.

Regional and Local Impacts

Rather significant impacts occur at the regional levels in both the typical and worst case solutions. However, in the latter case impacts are considerably greater in magnitude. Corn production declines in some regions by as much as 10 to 12 million bushels in the typical case solution and by

Figure 1. Trend and year-to-year changes in U.S. Corn Production



U.S. Corn Production, 1962-1977

Year-to-year Change in U.S. Corn Production

Source: Adapted by EPA, C&E Economic Analysis Branch from various issues of USDA, ERS, Feed Situation for the 1962 - 1972 period.

considerably larger amounts in the worst case solution; however, in the latter case these impacts would not be expected to occur regularly over a period of years on the average based on available long term yield benefit data for use of organochlorines on corn. (Exhibit L).

IMPACTS OF SUSPENSION IN 1976

The impacts of the suspension on the corn sector during 1976, the first crop year of the suspension, would be somewhat less than during a typical year as indicated in the linear programming analysis. The major factors leading to the judgment are that (a) at least some supplies of chlordane/heptachlor would be available for use in 1976 from stocks produced prior to the effective date of the suspension July 29, 1975, (b) the outlook for supplies for substitutes for chlordane/heptachlor is quite favorable as indicated later in this testimony. Although we have not undertaken an evaluation of the amount of chlordane/heptachlor that might be available for use in 1976, a significant amount could be available as well as possible supplies of aldrin, which are authorized for use under the aldrin suspension. The magnitude of the remaining supplies for use in 1976 would be significant if the same proportion remained in the first year of the suspension as was the case with aldrin where 36% of a year's supply was available for use on corn (2.5 million acres in 1975 compared with nearly 7 million acres in 1973/74) (Exhibit H, Table 1). Impacts of the suspension in 1976 would not fall evenly on the various corn producing states. Impacts would be greatest on those states, such as Missouri, Illinois, and Indiana, where organochlorines were used most intensively during recent years.

ECONOMIC IMPACTS OF SUSPENDING CHLORDANE AND HEPTACHLOR ON AGRICULTURAL USES OTHER THAN CORN

The testimony presented in this section is a survey of agricultural uses other than corn for purposes of identifying the nature and extent of economic impacts of shifting to alternatives to chlordane and heptachlor under a suspension. The approach utilized in the review of these uses has included the following:

1. A review of the registered crop uses of chlordane and heptachlor on a crop (site)/pest basis. Registered crop/pest combinations were captured under an automated system and a printout made for purposes of reviewing the registered chlordane/heptachlor uses and the extent to which alternatives are also registered.
2. 1974 and 1975 state insecticide recommendations have been reviewed to determine existence of significant uses for which alternatives are limited or absent.
3. A questionnaire was sent to the chief entomologists in the states in December, 1974 to obtain current information on uses of pesticides containing chlordane and heptachlor and problems associated with cancellation/suspension.
4. Other literature and data were collected for use along with the review of registered and recommended uses (Items 1-3 above) to determine the extent of economic impacts with suspension.

Citrus

The impacts of suspending citrus use of chlordane and heptachlor is limited primarily to chlordane and to uses in the states of California and Florida. In each case, rather limited quantities of chlordane are used; however, potential economic impacts from a suspension are significant primarily in Florida.

In California, chlordane is used on citrus plantings to protect them from termites. Chlordane is also used to control the Argentine ant which interferes with natural predators of scale insects. In the absence of chlordane to control the Argentine ant, an alternative method of control would be foliar applications of parathion, malathion, carbaryl, and guthion to directly control pests. Foliar control is likely to upset current pest management programs, thus requiring a re-organization of foliar spray schedules on about 3% of California citrus acreage.

In Florida, organochlorines such as aldrin/dieldrin and chlordane/heptachlor are the preferred treatments for root feeding beetles in the eastern coastal area of Florida, commonly known as the Indian River Region. The consensus is that effective soil insecticide alternatives are not available for these rootfeeding beetles. In the area most seriously affected, there is a high water table which places root systems near the surface thus preventing traditional cultural control cultivation methods with the result that a foliar control program would need to be initiated.

Review of this situation dating back to the beginning of the aldrin/dieldrin hearings indicates that the Indian River area might cease production of citrus over a period of 10 years if no alternative methods of control are forthcoming. This change in the use of land could lead to a loss of 6% of current U.S. citrus production (Exhibit N). Income to landholders would be lessened as the land would probably be used for grass/beef production.

Hawaiian Pineapple

Chlordane/heptachlor is used to control ants which help spread the mealy bug wilt in pineapple groves in Hawaii. Velsicol estimated the annual use of heptachlor at 10,000 pounds. Mirex is the principal control for this pest with heptachlor being a back-up chemical. The Hawaiian pineapple industry has experienced fierce foreign competition in recent years, especially in the processed market. As a result, some areas are going out of production. If organochlorines are no longer available for control of the ants in pineapple, registered foliar alternatives would need to be used such as parathion, malathion, endosulfan, di-syson, disulfoton and diazinon. Adequate control with foliar sprays, however, is difficult to achieve. No economic impact is foreseen, however, due to a suspension of chlordane/heptachlor since mirex continues to be available and provides effective control.

Potatoes

Velsicol estimated that as many as 1.1 million pounds of chlordane were used to protect potatoes from insects in 1974. (Exhibit A). This large volume of use cannot be confirmed with other available data. USDA estimated chlordane use of only 33,000 pounds on potatoes in 1971. USDA No. 252). Wireworms are the primary insects controlled by chlordane, although some states recommend use of chlordane to control white grubs. Of fourteen states recommending chlordane for wireworms, only one state recommends chlordane exclusively (Exhibit 0). Six other states recommend non-chlordane controls exclusively for wireworms.

Major alternatives recommended for wireworms and white grubs include diazinon, dyfonate, parathion and phorate.

Idaho, the leading potato producing state, grows 26% of the United States potato crop (USDA 1974). While Idaho does not recommend an alternative for chlordane to control white grubs, the state recommends with regard to the white grub that: "Early plowing generally eliminates the need for soil insecticide treatment." (U. of Idaho, 1975).

Thus, a non-chemical technique is available for white grub control in Idaho. Washington, the second ranking potato state, did not report problems with cancellation of chlordane on potatoes (USDA/EPA Survey, 1975). Maine, which ranks third in potatoes, indicated crop rotations and diazinon for wireworm control in the USDA/EPA Survey.

Major impacts on potato production from suspension are not indicated. This is in line with USDA's analysis in 1972. (Ag. Econ. Report, No. 231, August 1972). Added control costs were estimated at $108,000 nationally.

Seed Treatment

Generally minimal or no economic impacts are anticipated from the removal of heptachlor as a seed treatment providing supplies of alternatives are available, as discussed below (See Exhibit P). Controversy surrounds the removal of heptachlor seed treatment in the Southwest; actual estimates of impact are undetermined due to lack of data.

Velsicol Chemical Corporation estimates about 269,000 pounds of heptachlor were used for seed dressing (treatment) in 1974.

It is estimated that between 4% to 9% of all grain seed was treated with heptachlor in five midwestern states (1970-1974), whereas 9% to 20% of all grain seed was treated with one of five major insecticides (estimates concerning the overall use of seed treatment in the United States are unavailable). Cancellation of heptachlor seed treatments will result in the use of lindane, diazinon or a combination of lindane/diazinon.

Indications are that lindane is in short supply presently and that plant capacity is not expanding (Exhibit V). A substantial portion of the heptachlor seed treatment use (total of 269,000 pounds in 1974) could not be made up readily by lindane. Diazinon is likely to be available, although the overall outlook for supplies of it is mixed. (Exhibit V). Volumes needed for seed treatment are small compared to total diazinon use (7 million pounds in 1972. EPA 540/1-74-001).

USDA estimated that seed treatment costs for corn, sorghum and small grains would increase from $70,400 to $125,400, or by $55,000 for the year 1971 (USDA/ERS - 509). Diazinon was substituted for heptachlor on a pound-for-pound basis, total of 11,000 pounds. No yield effects were projected.

Pest Control on Strawberries

Chlordane is recommended for use against strawberry insect pests in many states (Exhibit Q). The larvae of rootweevils and white grubs are serious pests in certain areas for which several states recommend chlordane and for which alternative controls are limited. Other chemicals such as diazinon and carbaryl reportedly are effective controls but are not registered at sufficiently high rates of application to provide effective control (response of New York entomologist to USDA/EPA survey in 1975).

Most California production, which equals 2/3 of the U.S. total, would not be affected. In 1974, chlordane was used on only 16 percent of 1974 acreage grown (8,300 pounds on 1,409 acres) (California Pesticide use report for 1974). The next four ranking states in terms of commercial strawberry production would be adversely affected at least to some extent. They are as follows in rank order according to percent of U.S. production:

Oregon	10%	Michigan	3%
Washington	5%	North Carolina	1%

If alternatives are unavailable for control of these pests in these commercially important production states, significant national impacts would occur on the production of strawberries. The extent of economic impact of shifting to alternative crops for affected growers is not known at this time. The impact of shifting to alternatives is minimized to some extent in the state of Washington since neither chlordane nor heptachlor currently provide consistently effective control over the weevils attacking strawberries in that state (response to USDA/EPA Survey, 1975).

The lack of alternatives is likely to have related affects from these and other pests in isolated less commercially important strawberry producing states. In particular, production impacts were projected in the USDA/EPA survey in Kentucky, Maryland, Missouri, Mississippi, Nevada, North Carolina, New York, Ohio, Tennessee and Wisconsin.

Pest Control on Tomatoes

A review of the state insect recommendations for 25 states indicates that few states are recommending chlordane for use on tomatoes in 1975 (Exhibit R). Those states are: Ohio, Florida, Colorado, Maine, Minnesota and South Dakota. One of the principal problem pests is cutworms for which dylox and toxaphene baits or sprays are recommended. Differentials in cost on a per acre basis are nominal, particularly in view of the high value of the crop on a per acre basis ($1,000/acre). As with control of cutworms in corn, use of baits can fail due to adverse weather conditions or inadequate scouting.

There may be as much as 320,000 pounds of chlordane used on tomatoes in the U.S. based on estimates provided by Velsicol. This estimate, however, seems far in excess of the other estimates of use of chlordane on tomatoes. An average of less than 9,000 pounds of chlordane per year were used in California (the leading tomato state) on tomatoes in 1972 - 1974 (California pesticide use reports). USDA estimates of 8,000 acres treated in 1971 (Ag. Economic Report No. 231, August, 1972). This report indicated a very small impact from cancellation of chlordane -- and added cost of $12,000 for alternative controls, with no yield reductions.

Pest Control on Other Minor Crops

A review of state recommendations, the USDA/ERS 1975 State Survey and available USDA surveys indicates frequent minor localized problems on various crops for which small amounts of chlordane/heptachlor are used, but no significant economic impact is foreseen for these crops in the vast majority of instances. (Included in this category are apples, hay and alfalfa, peanuts, soybeans, tobacco, and certain vegetables.) Growers with long standing insect control practices involving use of chlordane (and less often heptachlor) would need to seek out other alternatives and make necessary adjustments in their operations. These adjustments could be troublesome at times.

Suspension of chlordane/heptachlor would not be likely to adversely affect apple production. As much as 373,000 pounds of chlordane were reportedly used for apple production in 1971 (USDA's 1971 pesticide use survey). This large use could not be confirmed by a recent study. Apparently little chlordane/heptachlor is used on apples. Some dieldrin has been used for apple production in the past for which other organochlorines including chlordane might be a substitute in view of the aldrin/dieldrin suspension.

A very small amount of hay and alfalfa has been treated with chlordane and/or heptachlor in the past. As little as 20,000 acres are treated nationally. No impact is projected for a suspension of this use.

While more recent use data has not been available, USDA figures from 1971 show that as little as 100 pounds of chlordane were used on peanuts. Since peanuts are not thought to be treated to any significant extent with chlordane or heptachlor, no economic impact is expected from the suspension. Chlordane/heptachlor is not cited as a recommended treatment for peanuts in Georgia and Virginia, which account for nearly one half of U.S. peanut production,according to 1975 recommendations. In Georgia "insurance" treatment with any insecticide is not recommended. If white fringed beetle problems emerge, growers are encouraged to check with their county agent.

Limited acreage of soybeans is treated with organochlorines. Most entomologists do not recommend organochlorines for use in soybeans because of residue problems. In response to the 1975 USDA/EPA State Survey, only Arkansas and Missouri indicated a need for these materials on soybeans. No significant economic impact is likely from suspension of soybean use of chlordane and heptachlor.

Some chlordane/heptachlor is used on tobacco in the United States (21,000 acres in 1971 based on USDA survey). These chemicals are not cited in the 1975 state recommendations for several major tobacco states (Virginia, Kentucky, Georgia, South Carolina and North Carolina, which account for more than 85% of U.S. tobacco production as of 1973). Foliar use of chlordane and other organochlorines on tobacco in crops on nearby fields can cause residue problems (Publication entitled "1975 Tobacco Information," North Carolina Misc. Extension Publication No. 126, December, 1974, pp. 30-31).

Chlordane and heptachlor are used for soil treatments to protect vegetables from attack by wireworms and white grubs, particularly where vegetables follow pasture in a rotation. There could be slight yield reductions in the production of some vegetables with the use of alternatives, but precise figures are not available across the country (USDA/EPA Survey, 1975).

Lawn and Turf Control

A review was made of 1975 state insecticide recommendations for lawns, ornamental turf and golf courses on a representative-state basis by EPA Region, to determine the extent to which chlordane and heptachlor and alternative controls are recommended. These recommendations were summarized by pest (total of 18 states) and were used as a basis for computing costs of chlordane/-heptachlor treatments and costs of alternatives. The review indicated that recommendations are generally made for three categories of insects: turf or grass damaging, nuisance pests and those contributing to health hazards.

Chlordane is generally recommended for ants, white grubs, Japanese beetles, webworms, cutworms, armyworms, fleas, mites, crickets, grasshoppers, earwigs, chiggers, ticks, leafhoppers, wasps, bees, cicada killers, and earthworms based on the 18 state review (Exhibit S). Heptachlor is very seldom recommended. Most of the state recommendations include at least two recommended alternatives to chlordane for control of these pests. Alternatives often give annual control, but do not give control for as long as chlordane, which in some cases provides multiple-year control.

Cost savings are possible in shifting from chlordane to alternative soil insecticide treatments for lawn and turf. An evaluation of chlordane treatments compared to alternatives for 18 states in the 10 EPA regions was made for treatment of 11 pests based on state recommendations for those pests and 1975 insecticide prices typical of those at farm supply stores in the midwest. Lowest cost alternatives for the 11 pests averaged $10.57 per acre compared with $12.33 per acre for chlordane and $20.34 per acre if the second lowest cost alternatives to chlordane were used. For a golf course with 50 acres of fairways and 3 acres of greens, costs would range from $560.21 to $1,078.02 compared with the average for chlordane of $653.49. Other large scale turf treating, such as at cemetaries and parks, would be similarly affected on a per-acre basis.

A similar pattern of impacts is likely for the typical homeowner treating his yard for lawn insects. Cost reductions would be possible. Cost of treatment for a 1/5 acre yard could be affected up or down in a range of $5 or $10 annually. Considering the possibility for cost savings as well as modest cost increases depending upon which alternatives are used, a suspension of these uses of chlordane would not impose a hardship on a typical homeowner with lawn soil insect problems.

Home and Garden Uses

Chlordane is federally registered for control of a great number of insects inside the home. A review of 32 state insecticide recommendations for 1975 (Exhibit T) showed that chlordane was not advised as a control against many of these pests.

Table 1 is a compilation of controls for only those insects for which surveyed states recommended use of chlordane/heptachlor inside the home. This table is suggestive of the relative importance of chlordane/heptachlor in control of these insects. A number of states make no recommendations for these pests, and when recommendations are made, a wide range of alternative controls are available and often times recommended in preference to chlordane/heptachlor. Some of the household pests are of such minor annoyance to the homeowner that states often recommend purely mechanical control.

The exception may be scorpions, and five of the six states recommending chlordane do not recommend any alternative chemical control. These five states are Alabama, Florida, Georgia, Oklahoma, and Oregon. However, the sixth state, New Mexico, recommends five alternatives. These are diazinon, baygon, vapona, malathion and ronnel. Problems due to lack of adequate controls from the suspension of chlordane or heptachlor will be minor and any increase in cost to the homeowner would be minimal.

The 1975 State recommendations also recommended insect controls for home garden vegetables in the 32 states. Six common vegetables were selected for analysis. The summary of the state recommendations for insects for which chlordane or heptachlor are recommended are shown in Tables 2-7. Heptachlor was rarely recommended.

It should be noted that in Tables 2 through 7 of Exhibit T the insects for which chlordane is recommended are practically identical for each of the six selected crops. For all selected crops, chlordane is the sole recommended control for only one insect, the white-fringed beetle. This insect was reported as a garden pest by one state. In addition, a number of cultural controls are available for the home garden, and are often recommended by the states.

Tables 8-13 contain a summary of state recommendations for insects in the garden for which chlordane/heptachlor was not recommended, even though it is registered for use on these insects. There are many pests for which chlordane and heptachlor were not recommended in the 32 states.

Minor economic significance can be attributed to the suspension of home garden uses. The primary impact would be that home gardeners would need to become accustomed to using different chemicals.

Use on Ornamentals

Use of chlordane to treat for insect problems on ornamentals is estimated to be about 250,000 pounds annually (Exhibit A). Commercial nurseries may account for most of this use. There are some problems with ornamental insect pests like the black vine weevil for which chlordane is recommended and for which alternatives are limited (USDA/EPA Survey, 1975). In several states, it is recommended for only one pest (in 7 of the 15 states). A summary of state recommendations for 15 states indicates that chlordane is recommended for relatively few ornamental insect/pest combinations (Exhibit U). Cost impacts of suspension of commercial nursery use on ornamentals are likely to be nominal to the consumer purchasing such products, but would be significant to the nursery operator, e.g., less than $100 per year for an average nursery. These conclusions were reached on the basis of approximate cost relationships for chlordane and six alternates.

A large volume of nursery plants are treated with chlordane in USDA quarantine programs. The unavailability of chlordane for such treatments could prevent shipment of plants under current regulations. Costs of alternatives would be significantly greater than chlordane. The extent of chlordane use for this program is not known. (Maximum authorized USDA Animal Plant Health Inspection Service use for all programs was 204,300 pounds in 1972).

The Availability of Substitutes to Chlordane and Heptachlor

Overview

The economic impact of the proposed suspension will depend heavily upon the market availability of substitutes. Even though substitutes may be registered and efficacious against target pests, they are of no avail if industry is not in a position to deliver the substitutes, when and where needed. A number of factors during recent years have contributed to shortages in pesticides, e.g., strong export demand, shortages of feedstocks due to energy crisis, large crop acreages and generally strong demand for pesticides. The outlook for supply of insecticides for 1976 is quite good in general and, in particular, prospects are favorable for many of the major substitutes for chlordane and heptachlor.

If the proposed suspension were made effective in 1976 and if existing stocks of chlordane and heptachlor were permitted to be used, it would appear that industry could respond with adequate supplies as the transition is made to alternative insecticides. During a period of one or two years, it is possible to increase plant capacities to produce substitutes or to develop additional supplies of intermediates to adequately expand the supply of final products. Also, there are opportunities to expand the domestic supply in the short run by reducing exports or increasing imports. Increasing efficiency in use of insecticides with reduction of prophylatic treatment is likely to reduce demand for insecticides to some extent, with increasing environmental awareness of pesticide hazards, with integrated pest management programs in the states and with applicator certification/training programs now being implemented.

It is possible that a significant portion of current insecticide use involving chlordane and heptachlor may not need to be replaced by other treatments in view of the above considerations. Also, in a recent study it has been estimated that insecticides are needlessly used on significant portions of crops grown in the U.S. as follows:

Corn	50 percent
Sorghum	50-60 percent
Apples	20-30 percent

(A Study of the Efficacy of the use of Pesticides in Agriculture, by MRI and RvR, EPA Contract #68-01-2608, July, 1975).

A similar estimate for corn was reported in another recent study (Theodore Riedeburg Associates, Pesticide Use for Control of Soil Borne Insects in the States of Indiana, Illinois, Iowa and Missouri, Report conducted for OPP, EPA, August, 1974).

EPA Survey

The supply outlook has been reviewed by EPA personnel with product managers of many of the major substitutes (Exhibit V). The review made by phone in late August and early September, 1975, indicates a generally favorable supply outlook. The products surveyed were furadan, dytonate, dasanit, mocap, sevin, bux, dursban, diazinon, ethion, aspon, orthene, toxaphene and lindane. The only clearly negative outlook was for bux, for which production is expected to decline due to corn rootworm resistance and for Lindane for which supplies are short. Diazinon, the only significant registered pre-emergence cutworm control, is not encouraging in terms of expanded production to meet potential demand in the corn cutworm (wireworm) market. If diazinon is not generally available, the only alternative is rescue baits and sprays for cutworm in corn.

Several of these products and others have been reviewed as alternatives to chlordane/heptachlor under EPA's Substitute Chemical Program. A brief tabular summary of data from these reviews is presented in Exhibit (W). These data generally indicate that prospects are favorable for supplies of these pesticides in the future.

USDA Pesticide Survey (1974-76)

USDA/ERS has just published a survey of the pesticide demand/supply situation for 1974, 1975 and 1976 (USDA-300). The survey covered 29 basic manufacturers of pesticides, those accounting for about three-fourths of U.S. production. The study indicates that substantial expansion of production capacity is planned or under way for 1976, including expansion for 13 insecticides. Expansion should substantially increase supplies in 1976 and availability of raw materials should continue to improve according to this study. Corn insecticide inventories are expected to be increased in 1975 as supply is expected to expand relative to demand by 12 percentage points (20 points in cotton). The USDA/ERS study also indicated that growers could usually obtain satisfactory substitute pesticides in 1974, despite frequent shortages for specific products and that supplies for 1975 were about adequate for that year's demand.

Energy Implications

The production of alternatives to chlordane will involve the use of less energy than chlordane on a pound for pound basis, based on a comparison with three carbamate and organophosphate substitutes (diazinon, carbofuran, and carbaryl)(Exhibit X). For heptachlor, slightly more energy would be involved per pound of active ingredient. Based on estimates of the rate of substitution of these alternatives for chlordane and heptachlor, there would be some reduction in total energy requirements taking into account electricity, coal for process heat and petroleum for feedstocks and inerts. The reduction would be 42,800 barrels of petroleum per year, which is minute compared to total U.S. petroleum use (about 13 million barrels per day).

Suspension would be likely to cause a net reduction in the use of some major insecticides in the United States, as was suggested by the response to the aldrin/dieldrin suspension in 1975 where total acreage of corn treated with all insecticides declined significantly on a national basis (Exhibit H). This phenomenon would reduce energy requirements for pesticide production. In some cases, however, replacement chemicals could require multiple applications, thus increasing use. This has not been documented on major uses.

Additional crop acreage brought into production to compensate for lower yields such as in corn would increase the amount of energy required to meet the demand for agricultural output. The extent of this impact would be small as the projected increase in acreage of U.S. food and feed grains is only 35,700 acres in a typical year.

On balance, the impact of a suspension on the nation's energy requirements would be very slight.

Conclusions

The review of the economic aspects of this suspension warrants the following general conclusions:

1. Chlordane/heptachlor is a major U.S. insecticide equalling about 1/20th of total insecticide use.
2. The use of these chemicals, as insecticides, generate significant economic benefits, most of which are available from the use of alternative controls.
3. Serious national macroeconomic effects on income and employment would not result from suspension.
4. Where significant economic impacts would occur, they would seldom be at the industry or sector level but rather in local areas or regions. Costs and incomes of corn growers would be affected where cutworms are a problem.
5. Economic affects on the consumer of food and other goods and services produced with the use of chlordane and heptachlor would not be significantly affected during a typical year of the suspension; however, under a worst case outcome situation with heavy infestations in many parts of the country and with failure of alternatives, impacts on the consumer could be significant in a given year.
6. The suspension would not contribute to the energy crisis.
7. The outlook for supplies of alternative controls is good.
8. Suspension would make it necessary for adjustments in a marketing system for pesticides to insure that supplies reach previous chlordane/heptachlor use pattern areas.
9. Users of pesticides, large and small, will need to make adjustments in the procurement and use of insecticides in previous chlordane/heptachlor use patterns and in some cases training would be useful to properly target new pesticides to economic thresholds.

EXHIBIT A

SELLERS, CONNER & CUNEO
ATTORNEYS AND COUNSELORS
1625 K STREET, NORTHWEST
WASHINGTON, D.C. 20006

(202) 347-0777
(202) 783-0870
CABLE SELCONCU

JOHN D. CONNER
GILBERT A. CUNEO
ROBERT L. ACKERLY
HERBERT L. FENSTER
C. STANLEY DEES
RAYMOND S. E. PUSHKAR
JAMES J. GALLAGHER
JOSEPH B. WAGER
CHARLES A. O'CONNOR, III
WILLIAM J. SPRIGGS

WILBUR [illegible] ADAMS, JR.
JEFFREY P. ALTMAN
STEVEN L. BRIGGERMAN
WILLIAM M. BUTTERFIELD
LAWRENCE S. EBNER
E. SANDERSON HOE
JOE G. HOLLINGSWORTH
ROBERT A. MAXSON
ALLAN W. MARKHAM
THOMAS L. PATTEN
NEIL H. RUTTENBERG
HARVEY G. SHERZER
KENNETH A. WEINSTEIN
WILLIAM J. WELLMAN
BUEL WHITE

HOMER CUMMINGS
1870-1956

ASHLEY SELLERS
JOEL P. SHEDD
OF COUNSEL

June 23, 1975

William Reukauf, Esquire
Room 519, West Tower
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Reukauf:

In your letter of March 28, 1975, you requested certain sales and distribution data regarding chlordane and heptachlor.

The distribution data are, of course, not readily available to Velsicol because it cannot control the products through the lines of distribution to the consumer. Velsicol personnel have made an appraisal, believed to be reasonably accurate, based on customers and their location, their type of business and formulations used. This appraisal is shown below for chlordane and heptachlor for the two most recent calendar years as requested.

Lbs. Tech Equivalent Chlordane

Crop	1973	1974
Corn	1,935,041	4,323,526
Potatoes	975,400	1,111,956
Other Vegetables	63,940	72,252
HL&G	5,773,016	6,328,577
Turf	1,136,413	1,249,063
Strawberries	151,921	166,541
Tomatoes	303,842	333,083
Ornamentals	227,882	249,812
PCO	7,413,777	7,342,255
Total	17,981,232	21,177,065

Lb. Tech Equivalent Heptachlor

Crop	1973	1974
Corn	1,133,128	1,187,393
Seed Dressing	189,760	268,797
PCO	613,711	551,669
Fire Ants, Misc.	32,735	44,412
Total	1,969,334	2,052,271

Within the category, "Fire Ants, Misc." there is included Heptachlor use on pineapples. Preliminary information from the Pineapple Research Institute of Hawaii indicates that approximately ten thousand pounds of Heptachlor is used annually in the production of pineapples. Additionally, Velsicol estimates that in 1975 approximately twenty thousand pounds of Heptachlor may be used in citrus production. This figure is based upon the fact that for the period 1971 through 1973 the Florida Department of Agriculture statistics show annual use of approximately twenty thousand pounds of Aldrin. Since the cancellation of Aldrin, Velsicol expects most citrus growers will turn to Heptachlor.

The PCO category in each case in the above tables is estimated to be primarily (more than 90%) termite use not in issue. Lastly, the usage breakdown shown above is distributed largely as you requested but modified to comprehend major use categories. Thus, uses which may be important to the user but which would not significantly affect totals are not shown.

Sincerely,

Charles A. O'Connor, III

CAO/paa

EXHIBIT B

TABLE I

PRODUCTION AND DESTINATION OF 23 SELECTED PESTICIDES (Millions of Pounds AI)

	U.S. Production	Imports	Exports	U.S. Use	Industrial/ Commercial	Government	Home and Garden	Agri- cultural	Geographical Regions[a]					
									NE	SE	NC	SC	NW	SW
Insecticides														
Aldrin	13.0	0	0.3	12.7	1.7	Small	Small	11.0	0.3	0.7	11.0	0.5	0.1	0.1
Carbaryl[b]	53.0	0	28.0	25.0	1.0	1.5	3.5	19.0	2.0	7.9	4.8	3.9	0.9	3.0
Carbofuran	6.0	0	1.0	5.0	Small	Small	Small	5.0	0.1	0.1	4.6	0.2	0.2	
Chlordane[b]	20.0	0	5.0	15.0	6.5	0.5	5.0	3.0	1.7	1.8	3.4	1.6	0.4	1.1
Diazinon[b]	12.0	0	5.0	7.0	1.2	0.8	2.0	3.0	0.4	0.8	2.1	0.6	1.1	
Disulfoton	5.0	0	Negligible	5.0	Small	Small	0.1	4.9	0.02	0.32	1.02	2.42	1.22	
Malathion[b]	24.0	0.2	8.0	16.2	4.0	2.2	5.0	5.0	1.1	3.5	2.5	1.8	1.0	1.3
Methyl Parathion	51.1	1.1	12.5	39.7	Small	Small	Small	39.7	Negligible	3.0	2.1	31.0	0.7	2.9
Parathion	14.0	Small	4.0	10.0	Small	Small	Small	9.9	0.4	1.4	1.8	3.5	2.9	
Toxaphene	76.0	0	18.0	58.0	1.0	Small	Small	57.0	0.1	20.1	1.2	31.7	4.7	
Subtotal[b]	274.1	1.3	81.8	193.6	15.4	5.0	15.6	157.5	6.22	41.72	32.32	77.22	10.82	
% U.S. use					8%	2.6%	8.1%	81.3%	3.2%	21.5%	16.7%	39.9%	9.7%	
Herbicides														
Alachlor	24.0	0	3.0	21.0	Negligible	Negligible	Negligible	21.0	1.3	0.8	17.4	0.8	0.5	
Atrazine	93.0	Negligible	20.0	75.0	1.7	0.3	1.0	72.0	2.5	5.5	37.3	7.7	2.0	
Bromacil[b]	4.0	0	1.0	3.0	2.3	0.3	0	0.4	0.2	0.3	0.4	0.8	0.2	0.6
2,4-D[b]	35.0	Negligible	7.0	48.0	6.0	3.0	3.0	34.0	2.0	4.1	21.1	7.0	7.8	3.0
Diuron[b]	6.5	0.7	0.5	6.7	3.8	0.4	Negligible	2.5	0.4	1.0	0.6	2.1	0.5	1.7
MSMA[b]	24.0	Negligible	5.0	19.0	4.0	1.0	1.5	12.5	0.4	2.5	1.4	11.6	0.7	0.9
Sodium Chlorate	600.0	30.0	Negligible	33.0[c]	19.0	1.0	Negligible	13.0	1.8	4.0	3.6	13.8	2.1	9.7
Trifluralin	21.0	0	4.0	17.0	Small	Negligible	Small	16.8	0.5	2.2	8.2	4.2	1.6	
Subtotal[b]	629.5	30.7	60.5	224.7	36.8	6.0	5.5	176.2	9.2	20.7	108.3	50.0	31.3	
% U.S. use					16.4%	2.7%	2.4%	78.6%	4.1%	9.2%	48.2%	22.3%	13.0%	
Fungicides and Wood Preservatives														
Captan[d]	17.0	Negligible	1.0	16.0	Negligible	Negligible	6.0	10.0	3.3	2.0	2.0	0.5	2.0	
Creosote	990.0	160.0	0	972[c]	970.0	Negligible	Negligible	2.0	165.3	165.3	300.6	185.3	90.15	65.15
Maneb[d]	12.0	0.1	4.5	7.6	Negligible	Negligible	1.6	6.0	1.8	1.5	1.5	0.3	0.9	
Pentachlorophenol	49.7	0	0.7	49.0	47.3	Negligible	1.3	Negligible	11.0	7.3	12.3	7.3	8.0	
Subtotal	1,068.7	160.1	6.2	1,044.6	1,017.3	-	9.1	18.0	181.8	156.3	317.6	193.6	186.2	
(Subtotal minus creosote)	(78.7)	(0.1)	(6.2)	(72.6)	(47.3)	-	(9.1)	(16)	(16.3)	(11.0)	(17.0)	(8.3)	(10.9)	
% U.S. use					97.4%	-	0.9%	1.7%	17.4%	15%	30.4%	18.5%	17.8%	
(% U.S. use minus creosote)					(65.4%)	-	(12.5%)	(22.0%)	(22.3%)	(15.2%)	(23.4%)	(11.4%)	(15%)	

TABLE I (Concluded)

	U.S. Production	Imports	Exports	U.S. Use	Industrial/ Commercial	Government	Home and Garden	Agri- cultural	Geographical Regions a/ NE	SE	NC	SC	NW	SW
Fumigants														
Methyl Bromide	25.0	Negligible	2.0	23.0	14.0	Negligible	Negligible	9.0	1.4	5.2	6.3	3.4	1.0	5.7
p-Dichlorobenzene	72.0	0	10.0	55.0f/	14.0	2.0	39.0	Negligible	14.7	9.3	14.4	9.3	2.0	5.3
Subtotal	97.0	-	12.0	78.0	28.0	2.0	39.0	9.0	16.1	14.5	20.7	12.7	14.0	
% U.S. use					35.9%	2.6%	50%	11.5%	20.6%	18.6%	26.5%	16.3%	17.9%	
Tin Compoundsg/	1.0	Negligible	0.35	1.45	0.8	-	-	0.65	0.23	0.31	0.28	0.30	0.33	
% U.S. use					55.2%	-	-	44.8%	15.8%	21.4%	19.3%	20.7%	22.8%	
Totals:	2,071.1	192.1	140.85	1,542.35	1,090.5	13	69.2	361.35	213.55	233.53	479.20	333.82	250.65	
% Total U.S. use					71%	1%	5%	23%	13.8%	15.1%	31.1%	21.6%	16.2%	
Totals - excluding creosote	1,001.1	32.1	140.85	570.35	128.5	13	69.2	351.35	48.05	88.23	178.60	140.52	73.35	
% Total U.S. use excluding creosote					23%	2%	12%	63%	8.4%	15.5%	31.3%	26.0%	13.2%	

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a/ See pp. 123-125 for states included in each region. Totals for NW and SW were not estimated separately for some products.

b/ Small amounts of some uses are not included in regional totals.

c/ Total domestic Na Chlorate use is 430 million pounds AI of which only 33 million pounds AI is pesticide use.

d/ Regional figures are for agricultural use only.

e/ Includes only wood preservation use; 178 million pounds AI is burned as fuel.

f/ Includes moth control and lavatory-space deodorant purposes only.

g/ Includes triphenyltin hydroxide (Du-Ter®), tricyclohexyltin hydroxide (Plictran®), and bis(tributyl)tin oxide (TBTO).

Source: EPA, Office of Pesticide Programs, Office of Water and Hazardous Materials, Production Distribution, Use and Environmental Impact Potential of Selected Pesticides, EPA 540/1-74-001.

TABLE II

ESTIMATED PRODUCTION, IMPORTS, EXPORTS AND DOMESTIC SUPPLIES OF SELECTED PESTICIDES BY CATEGORIES, 1972

	U.S. Production	Imports	Exports	Domestic Supply
Herbicides[a]				
Organic	451,300	12,200	76,400	387,100
Inorganic	41,000	Negligible	400	40,600
Subtotal	492,300	12,200	76,800	427,700
Insecticides[b]				
Organic	442,700	5,600	174,900	273,400
Inorganic	7,000	Negligible	1 600	5,400
Subtotal	449,700	5,600	176,500	278,800
Fungicides[c]				
Organic	83,000	5,200	24,000	64,200
Inorganic	60,000	Negligible	5,300	54,700
Subtotal	143,000	5,200	29,300	118,900
Fumigants,[d] Soil Conditioners	121,000	Negligible	38,900	82,100
Penta- and Tri- Cl-Phenols	70,000	Negligible	1,500	68,500
All Pesticides[e]				
Organic	1,168,000	23,000	315,700	875,300
Inorganic	108,000	Negligible	7,300	100,700
Totals	1,276,000	23,000	323,000	976,000

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[a] Includes defoliants, desiccants, plant growth regulators, chlorates.

[b] Includes miticides, nematicides, rodenticides, repellents.

[c] Excludes sulfur, creosote, coal tar, penta- and trichlorophenols.

[d] Excludes p-dichlorobenzene and certain other fumigants (see p. 11).

[e] Excludes sulfur, creosote, petroleum, coal tar, p-dichlorobenzene, etc. (see pp. 11 and 16).

Source: EPA, OPP, OWHM, op. cit. (1974).

TABLE III

DOMESTIC USE OF 25 INTENSIVE-STUDY PESTICIDES BY GOVERNMENTAL AGENCIES[a]

Pesticide[b]	Federal Agenices	State Agencies		Municipal Agencies		Estimated Total Governmental Use (million lb)
		Reported in Survey	Estimated Total	Reported in Survey	Estimated Total	
Aldrin	907	4,565	6,253	0	--	0.008
Carbaryl	1,016,648	252,239	345,533	2,659	29,220	1.5
Carbofuran	281	1,000	1,370	0	--	0.002
Chlordane	328,107	22,498	30,819	932	10,242	0.5
Diazinon	767,377	10,303	14,114	2,000	21,978	0.8
Disulfoton	1,796	761	1,043	0	--	0.003
Malathion	695,085	980,488	1,343,134	17,913	196,846	2.2
Methyl parathion	6,063	421	577	0	--	0.007
Parathion	1,495	228	312	0	--	0.002
Toxaphene	30,084	3,299	4,519	300	3,297	0.04
Alachlor	383	3,114	4,266	75	824	0.006
Atrazine	53,707	88,415	121,116	0	--	0.3
Bromacil	36,327	113,673	155,723	69	758	0.3
2,4-D	1,708,824	320,610	439,192	3,065	33,681	3.0
Diuron	32,165	123,341	168,960	160	1,758	0.4
MSMA	37,677	191,768	262,696	516	5,670	1.0
Sodium chlorate	145,109	340,796	466,844	97	1,066	1.0
Trifluralin	894	6,804	9,321	0	--	0.01
Captan	7,355	7,810	10,699	71	780	0.02
Creosote	0	0	--	0	--	0.5
Maneb	21	1,858	2,545	0	--	0.003
PCP	< 1	298	403	0	--	0.001
Tin Compounds	--	0	--	0	--	0.00
Para-dichlorobenzene	6 gal.	607	832	0	--	2.0
Methyl bromide	43,053	112,082	153,537	< 1	5	0.2
Totals	4,899,053	2,586,983	3,543,513	27,857	306,125	13.8

a/ Source: MRI survey and Reg. 42.
b/ Data are in pounds except as noted.

Source: EPA, OPP, OWHM, op. cit. (1974).

EXHIBIT C

Agricultural use of chlordane by type of use, U.S., 1964, 1966 and 1971 (active ingredient basis)

Year	Type of Agricultural Use			
	Crops	Livestock[a]	Other[b]	Total
	1,000 pounds a.i.			
1964	383	142	20	545
1966	452	71	3	526
1971	1,496	366	28	1,890
	Percent of Total			
1964	70.3	26.0	3.7	100
1966	85.9	13.5	0.6	100
1971	79.1	19.4	1.5	100

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[a] Includes livestock buildings

[b] Includes all other non-livestock and non-crop uses.

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 131, 179 and 252).

EXHIBIT D

Chlordane use on crops, U.S., 1966, 1971

Crop	Quantities 1966	Quantities 1971	Acres Treated 1966	Acres Treated 1971
	1,000 pounds active		---1,000 acres---	
Corn	159	842	210	533
Other grains	-	41	-	78
Cotton	3	-	6	-
Tobacco	26	2	17	1
Potatoes	155	33	38	55
Other field crops	1	29	2	16
Alfalfa	41	-	36	-
Other hay and pasture	6	2	23	3
Irish potatoes	155	33	38	55
Other vegetables [1/]	18	16	23	7
Citrus	15	18	83	10
Apples	3	373	3	10
Other fruits and nuts	24	7	31	4
Nursery and greenhouse	1	133	NA	NA
TOTAL	452	1,496	472	717

Note: In 1964, USDA included chlordane in the category of "Other organochlorine insecticides."

[1/] Includes strawberries.

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 179 and 252).

EXHIBIT E

Agricultural use of heptachlor by type of use, U.S., 1964, 1966 and 1971 (active ingredient basis)

Year	Type of Agricultural Use			
	Crops	Livestock[a]	Other[b]	Total
	1,000 pounds a.i.			
1964	1,301	-	4	1,305
1966	1,513	3	20	1,536
1971	1,143	-	68	1,211
	Percent of Total			
1964	99.7	-	0.3	100
1966	98.5	0.2	1.3	100
1971	94.4	-	5.6	100

---

[a] Includes livestock building

[b] Includes all other non-livestock and non-crop uses

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 131, 179 and 252).

EXHIBIT F

Heptachlor Use on Crops, U.S., 1964, 1966, 1971

Crop	Quantities			Acres Treated		
	1964	1966	1971	1964	1966	1971
	----1,000 pounds active-----			------1,000 acres---------		
Corn	1,099	1,484	1,104	1,427	2,026	1,901
Cotton	a/	-	-	a/	-	-
Tobacco	24	7	-	17	3	-
Alfalfa	-	3	3	-	12	14
Other hay and pasture	-	18	1	-	48	2
Other field crops	169	b/	-	279	4	-
Other vegetables	a/	1	34	a/	6	10
Apples	-	-	1	-	-	c/
Citrus	-	b/	-	-	-	-
All other fruits and nuts	-	b/	-	-	2	-
TOTAL	1,301	1,513	1,143	1,727	2,103	1,927

a/ Less than 10,000 acres treated.

b/ Less than 500 pounds.

c/ Less than 500 acres.

SOURCE: USDA/ERS (Agricultural Economic Report Nos. 179 and 252).

EXHIBIT G

SUMMARY OF EPA REGISTERED
INSECTICIDES FOR CORN INSECT PESTS
AND
1975 STATE RECOMMENDATIONS FOR CORN

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975

Table 1

EPA registered non-foliar controls for rootworms, cutworms and wireworms in corn, 1975

Pesticide Chemical	Rootworms	Cutworms	Wireworms
Chlordane	x	x	x
Heptachlor	x	x	x
Bux	x	-	-
Carbaryl		x	-
Carbofuran	x	-	x
Counter	x	-	x
Dasanit	x	-	x
Diazinon	-	x	x
Di-Syston	x	-	-
Dyfonate	x	-	x
Mocap	x	-	x
Parathion	x	x	x
Phorate	x	-	x
Toxaphene	-	x	

SOURCE: Preliminary summary of registered chlordane and heptachlor uses and alternatives, Criteria and Evaluation Division, OPP, EPA.

Table 2. Controls recommended for cutworms in corn in major corn growing states, 1975.

State	Pre-emergence			
	Aldrin	Heptachlor	Chlordane	Diazinon
Illinois	-	-	-	-
Indiana	Br	Br	Br	Br
Iowa	B,Br	B,Br	B,Br	-
Kansas	Br	Br	-	-
Michigan	-	-	-	F
Minnesota	Br	Br	Br	B
Missouri	Br	Br	Br	Br
Nebraska	Br,B	Br,B	Br,B	Br
Ohio	-	Br	Br	-
South Dakota	-	Br	Br	B

State	Rescue					
	Carbaryl		Toxaphene		Trichlorfon	
	Bait	Spray	Bait	Spray	Bait	Spray
Illinois	x	x	-	-	x	x
Indiana	x	x	-	x	x	x
Iowa	x	x	-	x	-	x
Kansas	x	-	-	x	x	-
Michigan	-	x	-	-	-	x
Minnesota	x	x	-	x	-	x
Missouri	x	x	-	x	-	x
Nebraska	x	-	-	-	-	-
Ohio	x	x	-	x	-	x
South Dakota	x	x	-	x	-	x

Legend:
Br - Broadcast Treatment
B - Band Treatment
F - Foliar Treatment
x - Rescue

Source: State insecticide recommendations, 1975.

Table 3

Controls recommended for wireworms in corn, major corn growing states, 1975

State	Chlordane	Heptachlor	Aldrin	Non-organochlorine alternatives							
				Carbofuran	Dasanit	Diazinon	Dyfonate	Mocap	Phorate	Parathion	Counter
Illinois	-	-	-	F	B	B	B	B	B	-	F
Indiana	Br	Br	Br	F	B	Br	Br	B	B	-	-
Iowa	F	F	F	B,F	B	Br	B	B	B	-	-
Kansas	-	-	-	B	B	-	B	B	B	-	-
Michigan	B,Br	-	-	-	-	B,Br	B,Br	-	-	-	-
Minnesota	Br	Br	-	-	B	Br	B,Br	-	B	-	-
Missouri	Br	Br	Br	B	B	Br	B,Br	-	B	-	B
Nebraska	Br,B	Br,B	Br,B	-	-	Br	-	-	-	-	-
Ohio	-	Br	Br	-	-	-	-	-	-	-	-
South Dakota	-	Br	Br	-	-	-	-	-	-	-	-

Legend: B - Band Treatment

Br - Broadcast Treatment

F - Furrow Treatment

Source: State insecticide recommendations, 1975

Table 4

Controls recommended for rootworms in corn, major corn growing states, 1975

State	Bux	Carbofuran	Dasanit	Dyfonate	Di-syston	Landrin	Mocap	Phorate	Diazinon	Counter	Lorsban	Chlordane
Illinois	-	B	B	B	-	-	-	B	-	B	-	-
Indiana	B	B	B	B	-	-	B	B	B	B	B	-
Iowa	-	B,Bt	B,Bt	B,Bt	-	-	B,Bt	B,Bt	St	B	-	-
Kansas	-	B	B	B	-	-	B	B	-	B	-	-
Michigan	B,Br	B,Br	B,Br	B,Br	B,Br	-	B,Br	B,Br	B,Br	-	-	B,Br
Minnesota	-	B	B	B	-	-	B	B	-	B	-	-
Missouri	B	B,F,Bt	B,Bt	B,Bt	Bt	B	B,Bt	B,Bt	B,Bt	B,F	B	-
Nebraska	Bt	B,Bt	B,Bt	B,Bt	Bt	-	Bt	B,Bt	B,Bt	B	-	-
Ohio	-	B,F	B	B	-	-	B	B	-	-	-	-
South Dakota	-	B	B	B	-	-	B	B	-	B	B	-

Legend: B - Band Treatment

Br - Broadcast Treatment

Bt - Basal Treatment

F - Furrow Treatment

Source: State insecticide recommendations, 1975

EXHIBIT H

DETAILED DATA ON USE OF CHLORDANE/HEPTACHLOR AND OTHER INSECTICIDES ON CORN, 1973/1974 and 1975

Arnold L. Aspelin

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975

Table 1. Acreage and number of farms applying insecticides on corn, by chemical, U.S. 1973/1974 average and 1975

Treatment	Acreage		Percent of acreage		Farms		Percent of farms	
	1973/74	1975	1973/74	1975	1973/74	1975	1973/74	1975
	000		Percent		No		Percent	
Aldrin	6,979	2,513	9.6	3.3	68,145	23,221	7.0	2.6
Belt/Chlordane	921	1,176	1.3	1.6	10,689	12,031	1.1	1.3
Heptachlor	898	1,432	1.2	1.9	8,519	15,481	0.9	1.7
Sevin	5 3	432	0.7	0.6	9,134	4,393	0.9	0.5
Bux-ten	1,851	243	2.5	0.3	24,892	5,648	2.6	0.6
Furadan	8,031	10,148	11.0	13.4	70,995	85,563	7.3	9.5
Counter	-	324	-	0.4	-	3,766	-	0.4
Diazinon	596	324	0.8	0.4	9,686	2,510	1.0	0.3
Mocap	-	24	-	0.0	-	-	-	-
Di-syston	.638	459	0.9	0.6	5,549	5,021	0.6	0.6
Thimet	4,692	4,865	6.4	6.4	45,035	49,999	4.7	5.6
Dasanit	556	1,081	0.8	1.4	6,390	9,414	0.7	1.0
Dyfonate	1,901	3,055	2.6	4.0	18,497	21,339	1.9	2.4
Toxaphene	-	-	-	-	-	-	-	-
Other	1,314	1,075	2.0	1.4	26,317	13,400	2.7	1.5
Total treated*	27,899	26,196	38.3	34.6	260,989	211,223	27.0	23.5
Not treated	44,977	49,407	61.7	65.4	706,791	686,254	73.0	76.5
Total	72,876	75,603	100.0	100.0	967,780	897,477	100.0	100.0

*Total treated acres and farms do not add because more than one chemical was applied on some acres and farms.

Source: Contract market study for Economic Analysis Branch, OPP, EPA
by Doane Agricultural Service, St. Louis, Missouri (EPA contract
#68-01-1928).

Table 2

Acreage of corn insecticide treatments on commercial farms, by chemical,

in major corn states and in U.S., 1975

Insecticide	Illinois	Indiana	Ohio	Wisconsin	Iowa	Minnesota	Missouri	Nebraska	Total (8 states)	Other States	U.S.
	Acreage (000)										
Aldrin	547	654	257	-	422	56	523	63	2,322	191	2,513
Belt/Chlordane	335	242	123	14	40	52	109	10	929	247	1,176
Heptachlor	380	112	-	-	502	-	245	-	1,239	193	1,432
Sevin	-	-	-	-	-	-	-	42	42	390	432
Bux-ten	-	-	-	17	114	7	47	21	206	37	243
Furadan	1,253	396	319	826	1,950	883	132	1,832	7,591	2,557	10,148
Counter	-	-	-	-	80	-	-	56	136	188	324
Diazinon	59	26	-	25	-	-	-	21	131	193	324
Mocap	-	-	-	-	-	24	-	-	24	-	24
Di-syston	-	-	-	-	-	-	-	28	28	431	459
Thimet	846	36	-	354	1,477	300	-	770	3,783	1,082	4,865
Dasanit	63	-	-	30	302	-	-	317	712	369	1,081
Dyfonate	936	65	-	21	701	339	-	324	2,386	669	3,055
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	100	68	186	43	125	94	187	33	836	239	1,075
Total Treated	4,434	1,372	859	1,315	5,601	1,738	1,219	3,382	19,920	6,276	26,196
Not Treated	6,458	4,348	2,719	2,[illegible]	7,245	5,157	1,704	3,060	32,789	16,618	49,407
Total	10,892	5,720	3,578	3,413	12,846	6,895	2,923	6,442	52,709	22,854	75,603
	Percent of total acreage										
Aldrin	5.0	7.9	7.2	-	3.3	0.8	17.9	1.0	4.4	0.8	3.3
Belt/Chlordane	3.1	4.2	3.4	0.4	0.3	0.8	3.7	0.2	1.8	1.1	1.6
Heptachlor	3.5	2.0	-	-	3.9	-	8.4	-	2.4	0.8	1.9
Sevin	-	-	-	-	-	-	-	0.7	0.1	1.7	0.6
Bux-ten	-	-	-	0.5	0.9	0.1	1.6	0.3	0.4	0.2	0.3
Furadan	11.5	6.9	8.9	24.2	15.2	12.8	4.5	28.4	14.4	11.2	13.4
Counter	-	-	-	-	0.6	-	-	0.9	0.3	0.8	0.4
Diazinon	0.5	0.5	-	0.7	-	-	-	0.3	0.3	0.9	0.4
Mocap	-	-	-	-	-	0.3	-	-	0.1	-	0.1
Di-syston	-	-	-	-	-	-	-	0.4	0.1	1.9	0.6
Thimet	7.8	0.6	-	10.4	11.5	4.4	-	12.0	7.2	4.7	6.4
Dasanit	0.6	-	-	0.9	2.4	-	-	4.9	1.4	1.6	1.4
Dyfonate	8.6	1.1	-	0.6	5.5	4.9	-	5.0	4.5	2.9	4.0
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	0.9	1.2	5.2	1.3	1.0	1.4	6.4	0.5	1.6	1.0	1.4
Total Treated	40.7	24.0	24.0	38.5	43.6	25.2	41.7	52.5	37.8	27.4	34.6
Not Treated	59.3	76.0	76.0	61.5	56.4	74.8	58.3	47.5	62.2	72.6	65.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTES: (1) Data are for commercial farms only.

(2) Total treated acreage does not reflect multiple treatments and therefore may be less than total of individual insecticides listed.

(3) Data are preliminary, but major changes are not expected in final data.

Source: Contract market study for Economic Analysis Branch, OPP, EPA by Doane Agricultural Service, St. Louis, Missouri (EPA contract # 68-01-1978).

Table 3

Acreage of corn insecticide treatments on commercial farms, by chemical, in major corn states and in U.S., 1973/74 average

Insecticide	Illinois	Indiana	Ohio	Wisconsin	Iowa	Minnesota	Missouri	Nebraska	Total (8 states)	Other States	U.S.
	Acreage (000)										
Aldrin	1,541	1,187	720	-	1,548	80	996	188	6,268	711	6,979
Belt/Chlordane	229	147	130	25	43	68	11	23	676	245	921
Heptachlor	493	6	-	-	273	-	82	-	854	44	898
Sevin	-	-	-	-	-	-	-	241	241	302	543
Bux-ten	149	-	-	76	475	142	106	652	1,600	251	1,851
Furadan	938	190	101	694	1,587	907	77	1,852	6,346	1,685	8,031
Counter	-	-	-	-	-	-	-	-	-	-	-
Diazinon	98	64	-	24	-	-	-	96	282	314	596
Mocap	-	-	-	-	-	57	-	-	57	-	57
Di-syston	-	-	-	-	-	-	-	128	128	510	638
Thimet	1,049	53	-	337	1,347	254	-	571	3,607	1,095	4,692
Dasanit	51	-	-	50	125	-	-	245	471	85	556
Dyfonate	477	59	-	17	403	225	-	246	1,427	474	1,901
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	50	31	149	53	232	66	108	119	808	506	1,314
Total Treated	5,015	1,719	1,104	1,278	5,900	1,811	1,336	4,102	22,265	5,634	27,899
Not Treated	5,190	3,824	2,484	1,984	6,381	4,660	1,573	2,529	28,625	16,352	44,977
Total	10,205	5,543	3,588	3,262	12,281	6,471	2,909	6,631	50,890	21,986	72,876
	Percent of total acreage										
Aldrin	15.1	21.4	20.1	-	12.7	1.4	34.2	2.8	12.3	3.2	9.6
Belt/Chlordane	2.2	2.7	3.6	0.8	0.4	1.1	0.4	0.4	1.3	1.1	1.3
Heptachlor	4.8	0.1	-	-	2.2	-	2.8	-	1.7	.2	1.2
Sevin	-	-	-	-	-	-	-	3.6	0.5	1.4	0.7
Bux-ten	1.5	-	-	2.3	3.9	2.2	3.6	9.8	3.1	1.1	2.5
Furadan	9.2	3.4	2.8	21.3	12.9	14.0	2.7	27.9	12.5	7.7	11.0
Counter	-	-	-	-	-	-	-	-	-	-	-
Diazinon	1.0	1.2	-	0.7	-	-	-	1.5	0.6	1.4	0.8
Mocap	-	-	-	-	-	0.9	-	-	0.1	-	0.1
Di-syston	-	-	-	-	-	-	-	1.9	0.3	2.3	0.9
Thimet	10.2	1.0	-	10.3	10.9	3.9	-	8.6	7.1	4.9	6.4
Dasanit	0.5	-	-	1.5	1.0	-	-	3.7	0.9	.4	0.8
Dyfonate	4.7	1.1	-	0.5	3.3	3.5	-	3.7	2.8	2.2	2.6
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	0.5	0.6	4.2	1.6	1.9	1.0	3.7	1.8	1.6	2.3	2.0
Total Treated	49.1	31.0	30.8	39.2	48.0	28.0	45.9	61.9	43.8	25.6	38.3
Not Treated	50.9	69.0	69.2	60.8	52.0	72.0	54.1	38.1	56.2	74.4	61.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTES: (1) Data are for commercial farms only.

(2) Total treated acreage does not reflect multiple treatments and therefore may be less than total of individual insecticides listed.

(3) Data are preliminary, but major changes are not expected in final data.

Source: Contract market study for Economic Analysis Branch, OPP, EPA by Doane Agricultural Service, St. Louis, Missouri (EPA contract # 68-01-1928).

Table 4

Corn insecticide expenditures on commercial corn farms, by chemical,
in major corn states and in U.S., 1975

Insecticide	Illinois	Indiana	Ohio	Wisconsin	Iowa	Minnesota	Missouri	Nebraska	Total (8 states)	Other States	U.S.
	Insecticide Expenditures ($000)										
Aldrin	1,652	1,239	547	-	861	119	1,396	126	5,940	317	6,257
Belt/Chlordane	939	596	399	44	92	136	272	22	2,500	515	3,015
Heptachlor	851	272	-	-	1,170	-	691	-	2,984	410	3,394
Sevin	-	-	-	-	-	-	-	130	130	1,235	1,365
Bux-ten	-	-	-	75	394	28	135	88	720	108	828
Furadan	5,964	2,146	1,646	3,659	8,658	4,283	620	8,977	35,953	13,892	49,845
Counter	-	-	-	-	355	-	-	297	652	952	1,604
Diazinon	120	61	-	95	-	-	-	57	333	642	975
Mocap	-	-	-	-	-	122	-	-	122	-	122
Di-syston	-	-	-	-	-	-	-	94	94	1,439	1,533
Thimet	3,266	121	-	1,066	5,051	1,020	-	2,995	13,119	3,909	17,028
Dasanit	220	-	-	182	1,075	-	-	1,249	2,726	1,220	3,946
Dyfonate	3,632	241	-	89	2,468	1,539	-	1,345	9,314	2,631	11,945
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	421	194	502	141	354	231	978	106	2,927	963	3,890
Total	17,065	4,870	3,094	5,351	20,478	7,478	4,092	15,066	77,514	28,233	105,747
	Average Expenditure per Treatment Acre ($)										
Aldrin	3.02	1.81	1.67	-	2.04	2.13	2.67	2.00	2.56	1.86	2.49
Belt/Chlordane	2.77	2.46	3.24	3.14	2.30	2.62	2.50	2.20	2.69	2.09	2.56
Heptachlor	2.24	1.50	-	-	2.33	-	2.82	-	2.41	2.12	2.37
Sevin	-	-	-	-	-	-	-	3.10	3.10	3.17	3.16
Bux-ten	-	-	-	4.44	3.46	4.00	2.87	4.17	3.50	2.92	3.41
Furadan	4.76	4.21	3.09	4.43	4.44	4.85	4.70	4.90	4.74	5.43	4.91
Counter	-	-	-	-	4.44	-	-	5.30	4.79	5.06	4.95
Diazinon	2.03	2.23	-	3.78	-	-	-	2.70	2.54	3.33	3.01
Mocap	-	-	-	-	-	5.09	-	-	5.09	-	5.09
Di-syston	-	-	-	-	-	-	-	3.37	3.36	3.34	3.34
Thimet	3.86	2.17	-	3.01	3.42	3.40	-	3.37	3.47	3.61	3.50
Dasanit	3.49	-	-	6.05	3.56	-	-	3.94	3.83	3.31	3.65
Dyfonate	3.88	3.37	-	4.24	3.52	4.54	-	4.15	3.90	3.93	3.91
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	4.21	2.85	2.70	3.28	2.83	2.46	5.23	3.21	3.50	4.03	3.62
Average	3.85	3.55	3.60	4.07	3.66	4.30	3.36	4.46	3.89	4.50	4.06

NOTES: (1) Data are for commercial farms only.

(2) Data are preliminary, but major changes are not expected in final data.

Source: Contract market study for Economic Analysis Branch, OPP, EPA by Doane Agricultural Service, St. Louis, Missouri (EPA contract # 68-01-1928).

Table 5

Corn insecticide expenditures on commercial corn farms, by chemical,

in major corn states and in U.S., 1973/74

Insecticide	Illinois	Indiana	Ohio	Wisconsin	Iowa	Minnesota	Missouri	Nebraska	Total (8 states)	Other States	U.S.
	Insecticide Expenditures ($000)										
Aldrin	2,985	2,154	1,204	-	2,512	135	2,116	257	11,363	1,439	12,802
Belt/Chlordane	470	271	244	68	77	152	32	58	1,372	390	1,762
Heptachlor	779	9	-	-	565	-	176	-	1,529	49	1,578
Sevin	-	-	-	-	-	-	-	538	538	898	1,436
Bux-ten	419	-	-	226	1,570	444	340	1,988	4,987	691	5,678
Furadan	3,313	799	312	2,324	5,461	3,402	296	6,734	22,641	6,610	29,251
Counter	-	-	-	-	-	-	-	-	-	-	-
Diazinon	259	143	-	72	-	-	-	267	741	760	1,501
Mocap	-	-	-	-	-	219	-	-	219	-	219
Di-syston	1	-	-	-	-	-	-	336	336	1,238	1,574
Thimet	2,708	115	-	838	3,271	617	-	1,575	9,124	2,676	11,800
Dasanit	108	-	-	153	363	-	-	830	1,454	207	1,661
Dyfonate	1,340	199	-	44	1,095	727	-	714	4,119	1,306	5,425
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	114	71	371	177	590	238	290	204	2,055	1,969	4,[illegible]4
Total	12,492	3,759	2,125	3,898	15,502	5,932	3,250	13,500	60,478	18,233	78,707
	Average Expenditure per Treatment Acre ($)										
Aldrin	1.94	1.81	1.67	-	1.62	1.53	2.12	1.37	1.81	2.66	1.83
Belt/Chlordane	2.95	1.84	1.88	2.72	1.79	2.74	2.91	2.52	2.03	1.59	1.91
Heptachlor	1.58	1.50	-	-	2.07	-	2.15	-	1.79	1.11	1.76
Sevin	-	-	-	-	-	-	-	2.23	2.23	2.97	2.64
Bux-ten	2.81	-	-	2.97	3.31	3.13	3.21	3.05	3.12	2.75	3.07
Furadan	3.53	4.21	3.09	3.35	3.44	3.75	3.84	3.64	3.57	3.92	3.64
Counter	-	-	-	-	-	-	-	-	-	-	-
Diazinon	2.44	2.23	-	3.00	-	-	-	2.79	2.63	2.42	2.52
Mocap	-	-	-	-	-	3.84	-	-	3.84	-	3.84
Di-syston	-	-	-	-	-	-	-	2.63	2.63	2.43	2.47
Thimet	2.59	2.17	-	2.49	2.43	2.43	-	2.71	2.53	2.47	2.51
Dasanit	2.12	-	-	3.06	2.90	-	-	3.39	3.09	2.44	2.93
Dyfonate	2.81	3.37	-	2.59	2.72	3.23	-	2.90	2.69	2.76	2.85
Toxaphene	-	-	-	-	-	-	-	-	-	-	-
Other	2.28	2.29	2.49	3.34	2.54	3.61	2.69	1.71	2.54	3.89	3.06
Average	2.49	2.19	1.93	3.05	2.63	3.28	2.43	3.26	2.72	3.24	2.82

NOTES: (1) Data are for commercial farms only.

(2) Average expenditures for total treated acreage does reflect multiple treatments.

(3) Data are preliminary, but major changes are not expected in final data.

Source: Contract market study for Economic Analysis Branch, OPP, EPA by Doane Agricultural Service, St. Louis, Missouri (EPA contract # 68-01-1924).

EXHIBIT I

Number of corn farms reporting cutworms as a major problem on farm, number treating for problem and percent treating in major corn states and U.S., low, high and average years, 1969-75

	Illinois	Indiana	Ohio	Wisconsin	Iowa	Minnesota	Missouri	Nebraska	U.S.
No. farms reporting problem									
Low year	6,377	1,211	1,844	587	2,854	1,268	1,649	984	19,316
High year	16,730	8,072	5,201	2,590	17,270	2,634	11,981	4,263	70,886
Average	11,183	4,237	3,186	1,246	9,713	1,545	5,679	2,579	52,650
No. farms treating for problem									
Low year	3,410	606	1,008	185	2,107	437	1,607	250	12,985
High year	10,955	5,247	3,113	969	14,688	1,317	6,519	1,869	47,790
Average	7,993	2,563	1,644	564	7,364	711	4,231	970	32,280
Percent treating for problem									
Low year	53.4	48.1	[illegible]	15.3	62.4	34.4	54.4	25.0	52.3
High year	92.7	72.0	92.6	85.0	86.6	62.0	97.3	56.5	71.3
Average	71.0	61.0	52.0	45.0	76.0	46.0	75.0	38.0	61.0

Source: Contract market study for Economic Analysis Branch, OPP, EPA by Doane Agricultural Service, St. Louis, Missouri (EPA Contract # 68-01-1928).

EXHIBIT J

Insecticide costs for typical corn soil pest application in midwest, 1974

Target pest/ Method/Chemical	Formulation	Rate/acre	Cost/acre
Cutworms and wireworms (also grubs)			
Broadcast			
Aldrin	4#/Gal E.C.	2 qts.	$ 3.98
	20% G (granules)	10 lbs.	3.20
Heptachlor	20% G	10 lbs.	2.90
Chlordane	33% G	12 lbs.	3.60
	72% E.C.F.	2 qts.	4.45
Diazinon	14% G	14-28 lbs.	7.35
	Ag 500	2-4 qts.	15.00
Sevin (cutworm)	5% bait	10-20 lbs.	2.70
Dylox (cutworm)	4#/Gal.	1-2 pts.	1.90
Dyfonate	4#/Gal. E.C.	2-4 qts.	10.30
Band			
Aldrin	4# E.C.	1 qt.	$ 1.98
	20 G	5 lbs.	1.60
Heptachlor	20 G	5 lbs	1.45
Chlordane	33% G	6 lbs.	1.80
	72% E.C.F.	2 pts.	2.25
Diazinon	14 G	7-14 lbs.	4.90
	Ag 500	1-2 qts.	7.50
Sevin (cutworm)	80% S.P.	2-5 lbs.	2.25
Sevimol (cutworm)	4#/Gal.	1/2 Gal.	3.20
Western Rootworm (Band)			
Furadan 10G	7.5 lbs.	9 ozs.	$ 3.30
Thimet 15G	6.5 lbs.	8 ozs.	2.50
Dyfonate 20G	5 lbs.	6 ozs.	2.85
Modcap 10G	10 lbs.	12 ozs.	3.20
Dasanit 15G	6.5 lbs.	8 ozs.	2.85
Diazinon 14G	7 lbs.	8.5 ozs.	2.60
Diazinon 50W	1-2 lbs.	1.25-2.5 ozs.	4.50
Bux 10G	10 lbs.	12 ozs.	3.80

SOURCE: Theordore Riedeburg Associates, Pesticide Use for Control of Soil Borne Insects in Corn in the States of Indiana, Illinois, Iowa and Missouri, November 1974.

EXHIBIT K

REVIEW OF USDA STUDIES ON IMPACTS OF CANCELLATION/SUSPENSION OF CHLORDANE/HEPTACHLOR USE ON CORN

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September 1975

Review of USDA Studies on Impacts of Cancellation/ Suspension of Chlordane/Heptachlor Use on Corn

This exhibit summarizes results of earlier economic studies conducted on the impact of cancelling chlordane and heptachlor, including one study done on the impact of cancelling aldrin which relates also to the C/H cancellation. These earlier studies include estimates of impact on the year 1971.

Staff members of the U.S. Department of Agriculture have prepared brief economic impact analyses of the effects of discontinuing farm use of chlordane (1) and heptachlor (2). The USDA report on chlordane indicates there would be no yield impact, from the withdrawal of chlordane, on 210,000 acres assumed to be treated with chlordane in 1971. It was assumed that a combination of diazinon plus carbaryl at 2 lb per acre each would yield results comparable to chlordane in the control of corn pests. Two pounds of active ingredient of each of these pesticides was used as basis for computing differences in cost of chlordane. The result was a cost of $8.80 per acre compared with $2.03 per acre for chlordane, generating a total cost impact of $1.4 million (208,000 acres x $6.77 per acre). The results of this analysis are of limited value at this time for the following reasons:

1. The acreage of corn treated with chlordane is thought to be as much as five times the acreage shown in the USDA study (1.1 million acres in 1975 as shown in Exhibit H in contrast with USDA's estimate of 208,000).

2. Costs of the alternative of $8.80 per acre are excessive as compared with those in Exhibit H.

The heptachlor report (2) includes estimates of cost and yield impact of non-organochlorine alternatives to heptachlor for the year 1971. A total of 669,000 acres were assumed to be treated with heptachlor for corn soil insects, mainly in the state of Illinois (262,000 acres for rootworms and 407,000 acres for other soil insects). No yield impacts were assumed for rootworm control, but a yield reduction of two bushels per acre was assumed for the 407,000 acres where other soil insects are a problem. The result was a reduction in corn production of about 800,000 bushels, mostly in Illinois but with some reductions in Missouri, Minnesota and other states. The reduction in corn production of 800,000 bushels amounts to a 0.014% reduction in production for the year 1971 (based on total production of 5.6 billion bushels in the U.S.). The reduction for the state of Illinois estimated to be 500,000 bushels amounted to a 0.047% reduction in production (based on total production of 1.067 billion bushels). Increased costs for alternative controls were estimated at $1.55 per acre for rootworms and $1.73 per acre for other soil insects giving a total costs impact of $1.11 million.

Estimated corn acreage treated with heptachlor in ERS's heptachlor cancellation impact analysis -- 669,000 acres for the year 1971 -- is inconsistent with USDA's 1971 Pesticide Use Survey which indicates that heptachlor was used on 1.1 million acres (USDA/ERS Report No. 252, July 1974, p. 43). If adjustment is made for the difference in acreage, and distribution of acreage treated for rootworms and other soil insects is maintained, the impact is increased by approximately 1.6 times or to 0.02% of the U.S. production, i.e., about 1.28 million bushels. It is not known whether such a transformation is entirely appropriate for 1971.

USDA also conducted a study of impacts of cancelling aldrin and other organochlorine insecticides for use on the aldrin treated acreage in the U.S. in 1971 (3). The study did not cover impacts on other acreage treated with organochlorines in 1971. If assumed no yield impacts for treatment of rootworms, but 0 to 12 percent reductions for wireworms among the states depending on whether alternatives were used in affected states and 0 to 30 percent reduction for cutworms. The study indicated reductions in U.S. corn production of 21.1 million bushels if alternative controls were used and 55.1 million if alternatives were not used. This reduction equals 0.4 to 0.8 percent of U.S. production in 1971. Taking into account market prices affected and cost impacts, the farm corn sector would experience a net income increase of $12.5 million to $76.4 million, depending on whether alternatives were used.

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
September 1975

References

(1) Jenkins, Robert P., Herman W. Delvo, and Austin S. Fox, *Economic Impact of Discontinuing Farm Use of Chlordane*, Agri. Report No. wel, ERS, USDA, Washington, D.C., August 1972.

(2) Delvo, H. W., A. S. Fox and R. P. Jenkins. *Economic Impact of Discontinuing Farm Uses of Heptachlor*. ERS-509, USDA, Washington, D.C., January 1973.

(3) Delvo, H. W., *Economic Impact of Discontinuing Aldrin Use of Corn* Production, Economic Research Service, USDA, ERS-557, Washington, D.C., June 1974.

EXHIBIT L

REVIEW OF DATA ON YIELD PERFORMANCE OF CHLORDANE/HEPTACHLOR AND OTHER INSECTICIDES IN CONTROL OF CORN ROOTWORMS, WIREWORMS, AND CUTWORMS

Arnold L. Aspelin
Fred Hageman

Economic Analysis Branch
Criteria and Evaluation Division
Environmental Protection Agency

September, 1975

Review of Data on Yield Performance of Chlordane/Heptachlor and other Insecticides in Control of Corn Rootworms, Wireworms, and Cutworms

This exhibit summarizes available data on the yield impacts of using chlordane/heptachlor vs. alternative controls for rootworms, wireworms and cutworms.

Yield benefits of the use of a given pesticide treatment depend on two critical factors: (1) ability of the treatment in controlling the target pest; (2) the level and frequency of infestation. Pesticides generate maximum benefits when they are highly effective in controlling the pest and when infestation levels are high.

Rootworms

Insecticide recommendations of the states reflect the general view of entomologists that rootworms are better controlled with non-organochlorine insecticides or by crop rotations, avoiding corn following corn. Accordingly, it is likely that there will be some increase in yields as alternates to organochlorines are used to control rootworms. As of 1971, 4.7 million acres were being treated with aldrin for rootworms (1) and 262,000 acres out of 669,000 acres of corn treated with heptachlor were treated exclusively for rootworms (39%) (2).

Inasmuch as alternative controls are more effective for rootworm than chlorinated hydrocarbons, shifting to ne of these will increase yields on a given field or reduce chances of damage from field-to-field or from year-to-year. Illinois data suggest yield increases from alternates in control of rootworms (Kuhlman and Petty, 1973) (3). This is consistent with reports obtained in 1973 from entomology department charmen in universities of major corn producing states. This survey, conducted by USDA, indicated that increased yeilds of up to 10 bushels per acre on those acres treated for resistant rootworms would result from going to non-organochlorine alternates in states of Iowa, Wisconsin, Missouri, Indiana and Illinois (4).

As an example, Turpin and Matthews estimate that in 1974 there were about 250,000 acres of continuous corn treated with aldrin in the northern third of Indiana where the western corn rootworm is established (5). They estimate that the minimum loss in Indiana on uncontrolled infestations of western rootworms is 5 bushels per acre. Therefore, if organophosphate or carbamate insecticides were used on those acres, there would be a saving of 1.25 million bushels (5).

The potential for increased yields from nonorganochlorine alternatives for rootworms was recognized by Delvo in 1974 (1, p. 6).

Wireworms

Wireworm yield effects tend to be spotty and most likely to occur in corn rotations following sod, pasture or idle acres. The spotty nature of wireworm problems was suggested by Munson (Missouri Survey Entomologist) who feels that wireworms are not much of a problem in the state and are limited to relatively few counties.[1] The sporadic nature of infestation frustrates the effort to target pesticide application so that economic returns cover the cost of treatment. Production impacts from the lack of organochlorine controls have been estimated variously from increased yield, to no effect, to yield reduction of five or more bushels per acre. In a USDA survey in 1973, yield impacts as follows were estimated by state entomologists: Iowa, 5 bu; Wis., 4 bu; Ill., 5 bu (Nebr. and Ind., no estimates given) (4). A survey of state entomologists and other professionals conducted by EPA in 1973 resulted in no specific estimates of yield reduction due to use of nonorganochlorines on wireworms.

Delvo contacted experts in the major corn growing states in 1973 to obtain estimates of yield impact from cancellation of organochlorines (1). He estimated no yield effects from alternatives for control of wireworms in Ohio, Indiana, and Illinois. He did estimate an 8% reduction in Iowa, Missouri, Lake States and Northern Plains, assuming alternatives are used under moderate to heavy outbreak conditions compared to control by organochlorines. The predictions seem rather extreme on the basis of history of losses in these states. A loss of 10% on the average for organochlorine-treated acres with 33% loss implies 33% of the acreage suffers that average level of damage (i.e., 33% of acreage x 33% loss = approximately 10% loss in production). This is unlikely to occur, judging from historical records on wireworm and other corn pest infestations during the last 25 years.[2]

For some species of wireworms, the necessity for organochlorines is also questionable based upon conversations with senior entomologists and on information from states, including their published recommendations. There is a likelihood that aldrin (or heptachlor) will fail under heavy outbreak conditions as indicated in the 1974 Missouri Recommendations (p. 55). In Iowa, Stockdale and Owens disagree as to the efficacy of aldrin and as to whether it is needed to control wireworms, thus raising the same issues relative to chlordane/heptachlor.

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[1] Munson indicated to EPA personnel while on a field trip to Missouri (May, 1974) that wireworms are not much of a problem in Missouri because infestations are so spotty and difficult to predict and treat. He prepared a map showing that infestations are limited largely to a 12 county area in the S.W. portion of this state and even there they are "spotty".

[2] Review of pest infestation/damage under USDA's cooperative Economic Insect Report Program for the midwest states for the last 25 years and review of weekly pest reports by the Department of Entomology, University of Missouri for the last 10 years. These data give some measure of insect incidences and damage, although there may be spotty reporting in the states covered (Review by Fred Hageman, EPA entomologist).

Recent test data from Illinois further indicate that certain organophosphate and carbamate alternatives are as effective as organochlorines in wireworm control.[1]

Another dimension to wireworm problems is that their life cycle is three or more years which makes it possible to achieve reduction in pest populations without treatment each year. Three year crop rotation and/or treatment schedules can reduce wireworm pest problems.

Illinois entomologists have tested baiting techniques to determine the presence of wireworms in sufficient numbers to call for treatment. They now recommend this practice to growers.

Cutworms

Aldrin and heptachlor are still effective for cutworm control even though we cannot assume that any chlorinated hydrocarbon will always reduce cutworm damage to less than economic levels. For example, extension entomologists from Missouri, a leading state in cutworm problems, cautioned farmers in 1972 that aldrin, heptachlor and chlordane applications "made at or prior to planting have not given desired results against cutworms in some instances." (8) They warned producers that a rate of 1 lb. a.i. in row treatment, a common practice, does not give acceptable cutworm control. Tillage and rainfall factors were also cited.

Turpin of Indiana reported that of five fields which had reported black cutworm infestation during 1972 and 1973, all of which had a moderate to severe problem, three had not been treated and two had been treated and two had been treated with aldrin, one by band and one by broadcast application. (9)

Petty of Illinois states:

> "The more serious problem of the black cutworm is not completely corrected by the use of chlorinated hydrocarbon pesticides, as evidenced by the fact county Extension advisers received over 90 complaints of cutworm damage in 1972 in fields in which aldrin, heptachlor and chlordane were used." (10)

In addition, the cutworm damage in corn fields in the Missouri bottomlands where aldrin is reported to be used by the vast majority of farmers would seem to indicate that aldrin is either being misapplied and/or is not effective enough to prevent injury under pressure of high populations.1/

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[1] Wireworm field trials in Illinois in 1975 (Cerro Gordo, Ill.) indicate that both carbofuran and Counter give good control of wireworms (tests at Greenview, Illinois, were less impressive). According to Dr. Luckman, who reports these results, Illinois will recommend such treatments where wireworms are suspected in 1976. This same series of tests also indicated good control of white grubs with carbofuran and Counter (Rochelle, Illinois, 1975).

Yield impacts were limited if they occurred at all when aldrin was denied to dairy farmers in Missouri for protecting corn against soil pests -- according to Keaster and Munson, state entomologists, and Taylor, a regional farm management specialist.2/

Cutworm damage, in terms of lost plants, can range to near 100% in extreme cases. Shaw and others reported damage in certain parts of fields in 1974 ranging from 6 to 85% (11), averaging 28% in the hot spots among 15 fields with damage. Of these 15 fields, 5 had been treated with organochlorines (11). According to Gaddy, a reduction in stand of 17% will reduce yield by 15% on Missouri bottomland (12). He also indicates that a reduction in plant population of 35 to 40% may result in replanting of corn or possibly planting of soybeans if the farmer has not used an organochlorine. One disadvantage of using a pre-emergence organochlorine insecticide in a high risk area is that soybeans cannot be planted should the corn stand be lost to insects, flood or other factors. An identical estimate was made by Thomas, Extension Entomologist, University of Missouri (May, 1974 meeting in Columbia, Mo.). No doubt some cutworm damage can occur without reduction in yield as some plants will regrow after being damaged and the loss of plants leaves more water and nutrients for nearby plants.

A comparison of aldrin-treated and non-treated areas of 13 bottomland fields in 6 Missouri counties indicated a yield differential of 7.93 bushels in favor of aldrin (120.69 vs. 112.76 bu.), an increase of about 7% yield while the plant population averaged only 3.5% higher (17,538 vs. 16,942) (13). This test was done on farm cooperator fields in bottomland areas. Although this test is not based on a large statistical sample and did not involve chlordane or heptachlor, it gives an indication of yield improvement with organochlorines under field conditions, compared to no treatment. Unfortunately, data were not available on the extent of infestation nor on any other alternative insecticides. Entomologists in Missouri indicate that research devoted to estimating yield improvement due to chlordane/heptachlor and alternatives has been frustrated by lack of areas with infestations of cutworms.3/

1/ Hershell Gaddy, regional extension agronomist in a three county high risk - bottomland area in Missouri, indicates that 20 to 25% of corn land must be replanted each year due to all causes, including cutworms and the serious problems of flooding. Much of it is treated with organochlorines like aldrin and heptachlor but often in furrow or band which does not control cutworms well and is not recommended.

2/ However, a recent study by Dr. Mahlon Fairchild (August 1975) reports that 27 of 205 dairy farms surveyed in 1973 indicated cutworm problems (13 percent). For 1972, the ratio was 21 percent. It is not known the extent to which these farms used organochlorines prior to 1972 or to which they experienced cutworm problems.

3/ Letter from Armon Keaster, Entomologist, University of Missouri, to Arnold Aspelin, EPA, 1974.

Dr. Luckman of Illinois (personal communication, 1975) indicates that the grower, on the average over a period of years will lose 1 bushel per day in May after the 10th of the month and 1.5 bushels per day in June for each day lost in the growing season. This means that the farmer who plants May 5 and replants May 30, will lose 20 bushels of yield. If insect, flood or other damage is widespread over the entire field, it may be completely replanted. However, he may also only replant portions of the field if damage is spotty, as it often is.

The extent of actual loss in a given year depends to a great extent upon the growing season. If it is a good growing year, replanting may incur little or no loss.

Key issues in estimating the impacts of shifting to alternative cutworm controls are the level of damage during an infestation and the probability or frequency of infestation. Let us now turn to the latter.

Infestations of cutworms are quite sporadic, although they tend to follow flooding and standing waters, either during the current year or from the previous year. The result is that even on the most risky cutworm land, one cannot expect to have a serious economic infestation in a given area more than 2 out of 5 years (Munson, Missouri - map prepared in May, 1974 (6). Similar frequencies are indicated in the 1974 Missouri insect control recommendations where treatment is recommended on soils subject to annual or frequent infestations (3 out of 5 years) and on first year corn after sod (14).

In 1974, an assessment was made of black cutworm damage in four counties in Illinois in connection with an integrated pest management program (15). The results were: (1) that black cutworm damage was nominal (less than three percent damage to plants, even in the most impacted county - Hancock); (2) that fields treated with aldrin and heptachlor had about the same levels of damage as untreated fields. Untreated acreage averaged 92.9 percent plants damaged less than 3 percent, compared with 96.7 with aldrin (100 percent for heptachlor, but the sample acre was very small for heptachlor). Of the 22,583 acres checked, only 142 acres had losses of 5 to 10 percent due to cut plants and only 20 acres had more than a 10 percent loss.

An Illinois study (11) indicates tentatively that black cutworm damage is associated with the following factors: previous outbreak on field, surface debris, soybeans the previous year, bottomland and poor drainage. If these factors can be verified, by further research, farmers can know whether to pre-plant treat and/or scout for possible cutworm damage. EPA is partially funding a large study in this area to determine the bionomics of the black cutworm, in order that it can be better understood and controlled. Lack of such data frustrates economic use of pre-plant treatments (as well as rescue). The time that the black cutworm is likely to strike is much easier to predict than where and at what level of infestation. Field entomologists can facilitate farmer scouting by alerting growers as to the most likely times for cutworm damage. According to Mr. Luckman, Illinois, it usually begins between

May 25 and June 1 and lasts for a relatively short period of time, for example, 3 or 4 weeks (personal communication, 1 August 1975).

According to Dr. Mahlon Fairchild in testimony at the aldrin/dieldrin suspension hearings, "A high risk field for cutworms....is one where we believe that, for one year in three, failure to treat will result in significant production loss". (16) Presumably, other fields would have less frequent losses.

Petty testified that cutworm damage at economic levels would not be expected to occur in more than 3 or 4 years out of 10 in the high risk area of Illinois (17).

In 1974, in response to a concerted effort by researchers on the corn soil arthopod research project to locate cutworm problem fields in the midwest, Turpir reports that very few significant infestations of black cutworms were found. The number of problem fields per state is as follows:

Indiana	16
Illinois	15
Missouri	4
Ohio	3
Iowa	9
Nebraska	0

Damage level varied from 2% plant reduction to the need to replant in three instances. A few of these fields were treated with chlorinated hydrocarbons (9).[1/]

An estimated 30 to 40% chance of infestation in high risk areas is confirmed by the previously mentioned research results in Missouri on 13 bottomland test fields (13). Five of the 13 fields showed a yield improvement from treatment of more than one bushel per acre (38%). The treated fields averaged 3.5% greater stand count, with treatment, as 5 fields had an improved stand of more than 500 plants per acre.

Based on the above views and data, it seems that no more than one-third of the corn fields now treated for cutworms with organochlorine would suffer significant economic damage in a typical year, in the absence of any treatment.

[1/] There is disagreement among midwest entomologists as to the interpretation of these data. For example, Dr. M. Fairchild does not feel that this is an accurate reflection of the number of fields with reportable problems.

Delvo of USDA, based on his survey of state entomologists in 1973, indicates the following average percentage yield reductions from cancelling organochlorines to control cutworms on total 1971 aldrin acreage (whether infested or not):

	With use of alternatives	Without use of alternatives
	percent	
Ohio	-5	-10
Indiana	-10	-25
Illinois	-10	-25
Iowa	-10	-25
Missouri	-15	-30
Lake States & Northern Plains	-10	-25
Other states	0	0

The Delvo report shows much higher yield improvement from treatment of cutworms with organochlorines in Missouri than can be justified on the basis of the only known Missouri field test on actual commercial farms (11). The yield improvement of 7.93 bushels per acre on the 13 fields is appropriately compared with the 30% loss figure for Missouri in the Delvo study, where no alternative insecticide was assumed to be used. The Delvo study calls for an impact more than four times larger than the empirical data indicate. Although 13 fields do not constitute a large statistical sample, these results suggest that Delvo's yield impacts are very high, more than one would expect to occur even in a moderate to heavy infestation.

A survey of state entomologists by USDA conducted in 1973 indicated yield reductions due to control of cutworm with nonorganochlorines in the range of 5 to 10 bushels per acre (4).

General Long Term Productivity of Organochlorines in Control of Corn Soil Pests

The above review of the productivity of chlordane and heptachlor in control of corn soil insects has a pest-specific focus and has not contemplated average productivity, i.e., increases in yields the individual grower or group of growers can expect to achieve over a period of years such as 5 or 10 years. There have been 2 such studies which indicate the general long-term productivity of organochlorines in the control of corn soil insects (19) (20).

The first of these two studies is by Bigger and Decker published in 1966 (19). This study is a summary of research covering the period 1954 to 1963, on a total of 130 tests conducted by the Illinois Experiment Station. Over that period, aldrin and heptachlor were tested for yield increases over no treatment with the result that yields were increased on the average of 5.7 bushels (6.4%). Differences between heptachlor and aldrin and between band and broadcast treatment were nominal, although aldrin and broadcast treatment of the two chemicals had slightly higher average yield increases during the period. Yield increases varied from -6.8% in 1962 to 11.7% in 1961 and 11.9% in 1958.

The other long-term study on the productivity of corn soil insecticides has just been completed by Peters (20) for the State of Iowa . Peters summarizes yield responses of tests conducted by the Iowa Experiment Station during the period from 1951 to 1962 on a total of nearly 200 tests. For corn-after-corn comparisons of aldrin, heptachlor and chlordane, the average yield improvement (compared to untreated land) was 9.14% (7.55 bushels) and 9.08% for first-year corn comparisons (9.46 bushels). The overall weighted average increase for both corn-after-corn and first-year corn was 9.13% or 8.05 bushels per acre. Yield increases varied from -12.3 bushels to a high of 75 bushels. Of the 198 comparisons, there were 10 in which the yield increase exceeded 20 bushels per acre, 5% of the time.

Comparable yield increases over untreated land were also reported in the article by Peters based on actual field observations on 939 fields during the period from 1961 to 1970 in the State of Iowa. A total of 378 fields treated with aldrin were compared with 561 fields that were untreated. The average benefit attributed to aldrin by Dr. Peters was 9.3 bushels per acre for an average increase of 9.33% over the untreated yield of 99.7 bushels during the period. Weather and management and other factors were not held absolutely constant by the research design. However, Dr. Peters feels that the benefit attributed to aldrin is appropriately so and in line with the test data generated during the previous decade.

These two long-term studies establish quite convincingly that the benefits of organochlorine treatments in the control of corn soil insects are generally in the range of 6 to 10% as an average expectation over a period of years and over a wide geographic area. There are no other known studies which indicate that benefits of corn soil insecticides on a long term basis generate benefits greater than those reported in these two articles.

The yield increases reported in these two studies indicate the magnitude of benefits attributable to the organochlorine pesticides during the period immediately following their introduction, before pest resistance developed. In other words, they indicate the benefits of organochlorine during the period of their most effective use in control of corn soil insects, including the rootworms, wireworms and cutworms. Unfortunately, these data are not available for other states; however, it is doubtful whether yield increase in other states would greatly (orders of magnitude) exceed those in these two states.

Table 1 contains a summary of two sets of yield coefficients for shifting from use of organochlorines to alternatives and to no treatment for rootworms, wireworms and cutworms. One set called "EPA Estimates" is the estimate of yield effects for use in the linear programming analysis, reflecting typical or average yield impacts to be expected over a 5 year time-frame such as 1975-80. The method used in deriving these are discussed below. The second set of coefficients ("Delvo Estimates") are those developed by Delvo.

The "EPA estimates" are values for yield benefits attributable to organochlorine insecticides, particularly heptachlor, aldrin and, to a lesser degree, chlordane in a long-term context such as five years for the major corn producing states. These estimates reflect the average benefits attributable to the organochlorines reported in the Illinois study (6.4%) and Iowa (9.1%). These averages were used along with the estimates of yield impact with and without alternatives to aldrin reported in Delvo's study in 1974. The general approach used was to accept Delvo's estimates in terms of their overall structure indicating relationships between types of control and among states, but to deflate the data in line with the long-term studies for Iowa and Illinois. The average amount of inflation in the Delvo estimates was by a factor of 2.89 in the State of Illinois and a factor of 2.23 for the State of Iowa on a weighted average basis for wireworms and cutworms. These two factors were based on weighting of wireworm and cutworm damage in proportion to the 1973/74 average estimates of infested acres treated for the 2 pests in the 2 states. Yield benefit compared to no treatment for states other than Illinois and Iowa were estimated at the average benefit in the long-term studies for Illinois and Iowa which was 7.8% (average of 6.4 and 9.1%).

Table 1. Estimated impact on average yields of alternative insecticide options, by state/regions, U.S., 1975-80

States	With alternatives			Without alternatives			With chlordane, heptachlor, aldrin		
	Rootworm	Wireworm	Cutworm	Rootworm	Wireworm	Cutworm	Rootworm	Wireworm	Cutworm
	------------------------------------ Percent					------------------	-------------------------------		
				EPA Estimates					
Ohio	0	0	-2.0	-7.8	-3.9	-3.9	-3.9	0	0
Indiana	0	0	-3.9	-7.8	-3.9	-9.8	-3.9	0	0
Illinois	0	0	-3.5	-6.4	3.5	-8.7	-3.2	0	0
Iowa	0	-3.6	-4.5	-9.1	-5.4	-11.2	-4.5	0	0
Missouri	0	-3.1	-5.9	-7.8	-4.7	-11.7	-3.9	0	0
Lake States and N. Plains	0	-3.1	-3.9	-7.8	-4.7	-9.8	-3.9	0	0
Other states	0	0	0	0	0	0	0	0	0
				Delvo Estimates					
Ohio	0	0	-5.0	0	-10.0	-10.0	0	0	0
Indiana	0	0	-10.0	0	-10.0	-25.0	0	0	0
Illinois	0	0	-10.0	0	-10.0	-25.0	0	0	0
Iowa	0	-8.0	-10.0	0	-12.0	-25.0	0	0	0
Missouri	0	-8.0	-15.0	0	-12.0	-30.0	0	0	0
Lake States and N. Plains	0	-8.0	-10.0	0	-12.0	-25.0	0	0	0
Other states	0	0	0	0	0	0	0	0	0

Sources: EPA Estimates: USDA/ERS - 557 and long term studies in Iowa (Peters, 1975) and Illinois (Bigger and Decker, 1966).
Delvo Estimates: USDA/ERS report no. 557, June 1974, by Herman Delvo.

The Delvo study recognized the possibility that yields could be improved by control of rootworms with compounds other than organochlorines. However, no estimate was made of this effect. We have estimated these rootworm yield effects at one half the yield improvement estimated for organochlorines over no control, as indicated in the long-term Illinois and Iowa data for all corn soil insects.

The data presented in Table 1, we believe, are an appropriate set of yield factors for estimating impacts over large geographic areas over a period of years, on a typical year basis. Whereas the benefits of control may vary from year to year, we believe that the estimates in this table are a reasonable approximation to what would be expected over a five year time frame in the various corn producing states, and we have, therefore, utilized these coefficients in a linear programming analysis of the impact of suspending or cancelling all of the organochlorine insecticides for use on corn during the period 1975 to 1980.

We have concluded that substantially higher numbers than these would not be reasonable approximations to what could be expected over a period of years. This is not to say that a given year could not produce greater or lesser benefits from control of corn soil insect pests. Undoubtedly, benefits will vary from year to year. However, our review of the history of corn soil insect control indicates that the exceptional years where large cutworm outbreaks occur cannot be fully anticipated, and, therefore, cannot be prevented by the use of the pre-emergence insecticides in any case. The improvements in pest scouting now being developed, tested and implemented to some extent in the states could improve that situation. Scouting for rootworms and wireworms appears to be well on its way to success. Much less progress has been made in being able to project economic infestations of cutworms.

Arnold L. Aspelin
Fred Hageman
Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
September 1975

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EXHIBIT M

DETAILED INFORMATION ON LINEAR PROGRAMMING ANALYSIS OF ORGANOCHLORINE SUSPENSION OF CORN USE IN UNITED STATES

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975

Detailed Information on Linear Programming Analysis of Organochlorine Suspension of Corn Use in the United States

Mathematical models of agriculture are tools for measuring the market effects of agricultural pesticide use. A subset of mathematical models, activity analysis, was chosen as the most appropriate tool for pesticide study because of its inherent assumptions which closely mirror the reality of the agricultural sector. Activity analysis assumes the maximization or minimization of a mathematically defined choice criterion (objective function) by the selection of economically feasible production activities from a finite set, constrained by available resources and required production (demand). The characteristics of the agricultural sector embodied in these assumptions are:

(1) Profit Maximization or Cost Minimization - Economic theory and observation of agricultural activity support the proposition that farmers attempt to maximize economic profit.

(2) Resource Adjustment - In response to changes in the price of inputs such as fertilizers, pesticides, capital, etc. and output, for example, a change in the price of corn relative to soybeans or changes in livestock prices, farmers adjust both their mix of inputs and their cropping patterns in order to maximize returns.

(3) Constraints - Resource constraints express the fact that economic activity requires the use of limited resources. Especially in agriculture, the limited supply of natural resources, particularly land, makes this a pertinent consideration. Constraints are defined on a regional basis to assure that available stocks of resources are not exceeded in the solution of the mathematical program.

A second set of constraints (non-physical) also limit the freedom of adjustment which farmers can make in response to varying economic signals. Unlike physical constraints such as a limited supply of land, this second set is subtle and difficult to specify. The set includes non-market influences, such as tastes and preferences, tradition, resource immobility, lack of information and ignorance. These constraints imply that farmers consider a very limited number of choices at decision time. Further, they imply that farmers' decisions, while directed at profit maximization, may not always be optimal. They are accounted for within the mathematical model through a system of flexibility penalties which limit adjustment to mirror observed rigidities.

(4) The fixed production requirements embodied in the model, while somewhat at variance with demand theory, provide a good approximation for agriculture. Demands for agricultural products are determined primarily by population size and are moderated by price and income. A portion of the demand within the model is fixed by population within various geographic regions while the remainder (the particular mix feedgrain consumption by livestock and poultry) is responsive to feedgrain prices.

The particular form of activity analysis chosen for the agricultural model developed to support pesticide policy research assumes that the resource constraints and production requirements can be defined as linear functions, and that the objective function is both linear and additive. Although these assumptions limit precision to some extent, it was felt that for the present, the more general formulation of activity analysis models would not provide enough additional information or justify the increased difficulty of construction and solution.

Analysis of the impacts of agricultural pesticide policy requires that the model be both national and interregional in scope. Markets for agricultural products are national in that equilibrium prices are determined through a summation process of individual production decisions. On the other hand, the model must be regionally specific to account for the physical relationships and methodology of agricultural production which vary among regions of the country. This construction places extreme emphasis on the economic phenomenon of interregional competition which is an important characteristic of the agricultural economy.

The purpose of the model is to analyze the economic impacts of changes in the use pattern of pesticides. The approach is to compare the differences in food costs, resource utilization, location of production, and agricultural incomes under two sets of conditions: (1) the suspect chemical allowed in its historical use patterns in combination with substitute chemicals and (2) the use of substitute chemicals.

Base Model

The base linear programming model contains approximately 19,000 activities (columns) and approximately 1,500 resource constraints and demands (rows). The activities include crop production (disaggregated by soil type and region), commodity transportation, conversion of commodities into feed nutrients, and conversion of feedgrains into corn equivalents for exports.

Resource constraints are defined for land by land class. Demands include those for specific commodities, livestock nutrients, feedgrains for export and specific commodity exports.

Seven crops are treated as endogenous to the model. These include barley, corn, cotton, soybeans, oats, sorghum and wheat. Other agricultural land uses are projected exogenously and subtracted from the total land base. The livestock sector is also projected exogenously and fixed at a predetermined level. The non-feedgrain portion of total nutrient demand for ruminants, non-ruminants and poultry is exogenous to the model and fixed at historically projected levels. Net nutrient requirements stated as digestible protein and total digestible nutrients which must be supplied from endogenous crops were calculated and stated as regional demands which must be met through local production or import from other regions. Other, non-feeding demands for endogenous crops, such as barley malt for brewing, corn for breakfast cereal, etc., are projected as a function of Series E population estimates and are added to regional demands to form the right hand side constraints which must be satisfied. A set of activities for production of the endogenous crops by region with variable yields disaggregated by three soil groups define the feasible set of activities which can be used to satisfy regional and export demands (estimated exogenously). Each production activity has a corresponding budget and yield. The budgets, which are disaggregated by variable input, e.g., labor, fertilizer, pesticides, machinery, allow the analyst easy access to the model for purposes of updating or changing the cost and/or quantity of variable inputs.

Regional Delineation

To reflect the real-world homogeneity of production functions and the national-interregional nature of markets, the 48 contiguous United States are partitioned into producing areas (PA's) and consuming regions (CR's). PA's are delineated so that a single production activity can be defined for a given crop in that area. CR's are defined to represent regions for which a single commodity market exists.

Producing Areas (PA's)

The United States is partitioned into 129 producing areas, each of which is an aggregation of counties (usually contiguous). Each PA is wholly contained within one state, and in some cases one producing area covers an entire state.

For most of the country, producing areas are defined in accordance with the Agricultural Production and Technology (APAT) PA's. The Economic Research Service, USDA, defined the APAT production areas as those areas within which similar cropping conditions prevail. In most regions the producing areas also encompass one or more of the Census of Agriculture subregions or state parts of subregions. Where APAT producing areas exist, the PA's in this study are consistent with them. The only exception is the case where APAT producing areas cross state boundaries. In this instance the APAT PA has been partitioned into two or more PA's which conform to state lines.

Where budget data for APAT regions were not defined, crop production data and cost estimates were generated with the assistance of economists at the

University of Illinois. Whole states for which this information was utilized include New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia, Florida and Kentucky. Portions of other states in the South and Southwest are also partitioned according to the University of Illinois budget data.

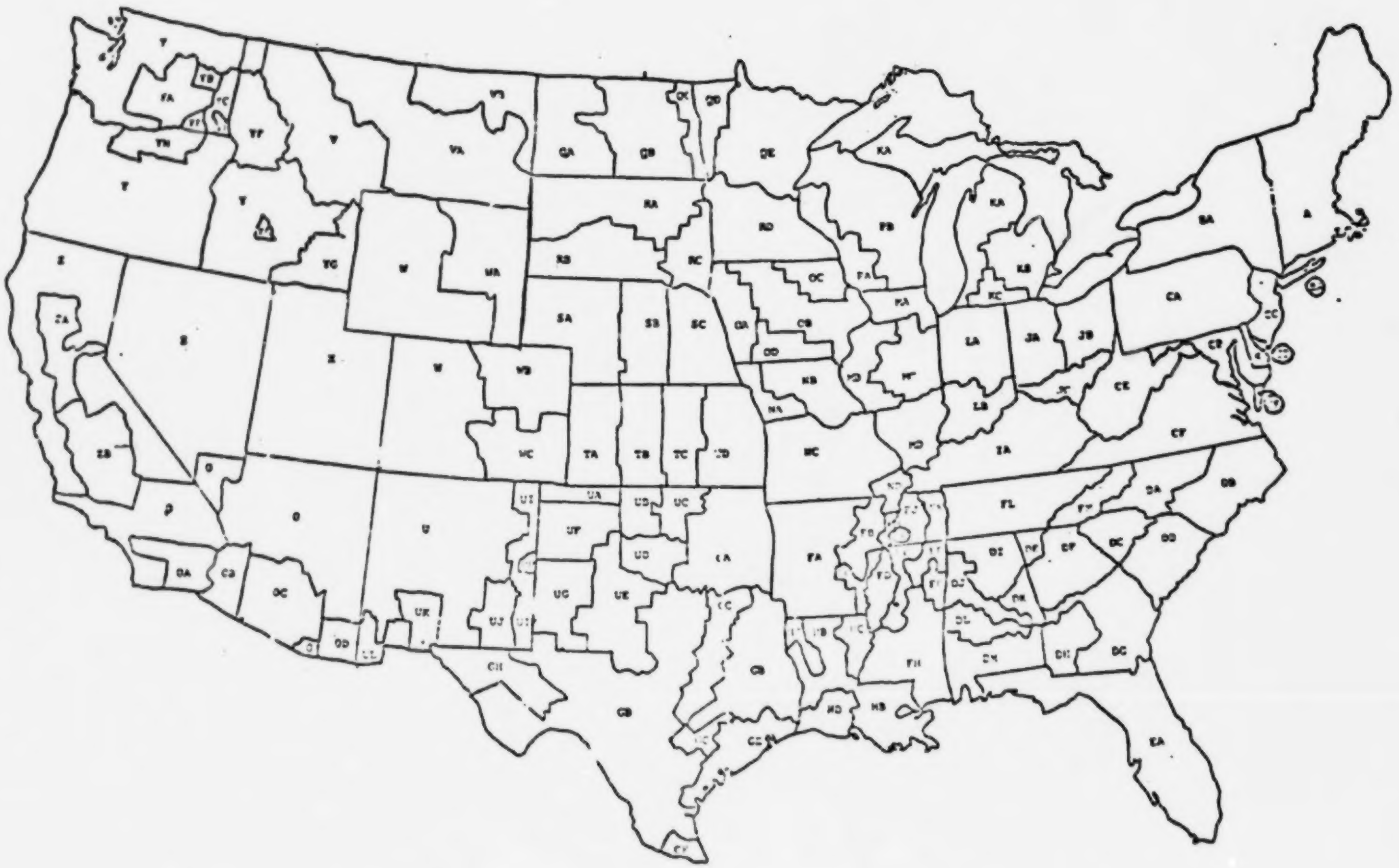
A map of the producing areas is shown in Figure 1. The first letter of the producing area name denotes the consuming region to which the PA is assigned, and the second letter denotes one PA within that CR. For example, the state of Missouri has been designated as the consuming region N, within which are four PA's: NA, NB, NC, and ND. Regions which are coded with a single letter are areas where budget data was not available, but where production was allowed at or below historic levels. Western New Mexico, for instance, is signified by the consuming region name, U, followed by a blank for the producing area code.

Consuming Regions (CR's)

The United States is divided into 27 consuming regions. Each consuming region is composed of contiguous producing areas. In most cases, the CR's are whole states or are aggregates of whole states. State boundaries are not observed in those cases where commodity markets do not follow them. States split include Minnesota, Oklahoma, Texas, California, and Nevada. In every instance it was felt that each part of the state lies in a separate market area. For instance, the Duluth market (Q) is more likely to include North Dakota than it is Southern Minnesota, while South Dakota and Southern Minnesota are more closely related.

Each consuming region is oriented toward a major metropolitan area and/or transportation center. The basis for selecting the city is central

Figure 1. Producing Regions.



place theory, which considers a city or region as occupying a position in an existing hierarchy of cities and regions. The central city in each consuming region is considered to be the city at the highest level within the region. Throughout this report the name of the central city is often used to signify the entire consuming region.

A map of the consuming regions is shown in Figure 2. The letters signifying the consuming regions range from A to Z, and the central city for each is designated on the map.

Major Regions (MR's)

Major regions are defined for reporting purposes only, and are not functional in the model. The consuming regions are aggregated into seven major regions in the United States. The formation of seven MR's permits an overview of the effects of policy changes on principal sections of the country. A map of the major regions is shown in Figure 3.

Solution

The model is solved through a mathematical algorithm which simultaneously guarantees that: (a) all regional demands are satisfied, (b) no regional resource constraint, e.g., disaggregated land base, is exceeded, and (c) the objective function is minimized. In so doing, the model solution depicts the land use and production pattern which satisfies all constraints at least cost.

An alternative construction would have been a profit maximization model which would provide a solution which maximizes returns to the agricultural sector. However, a unique characteristic of linear programming

Figure 2. Consuming Regions

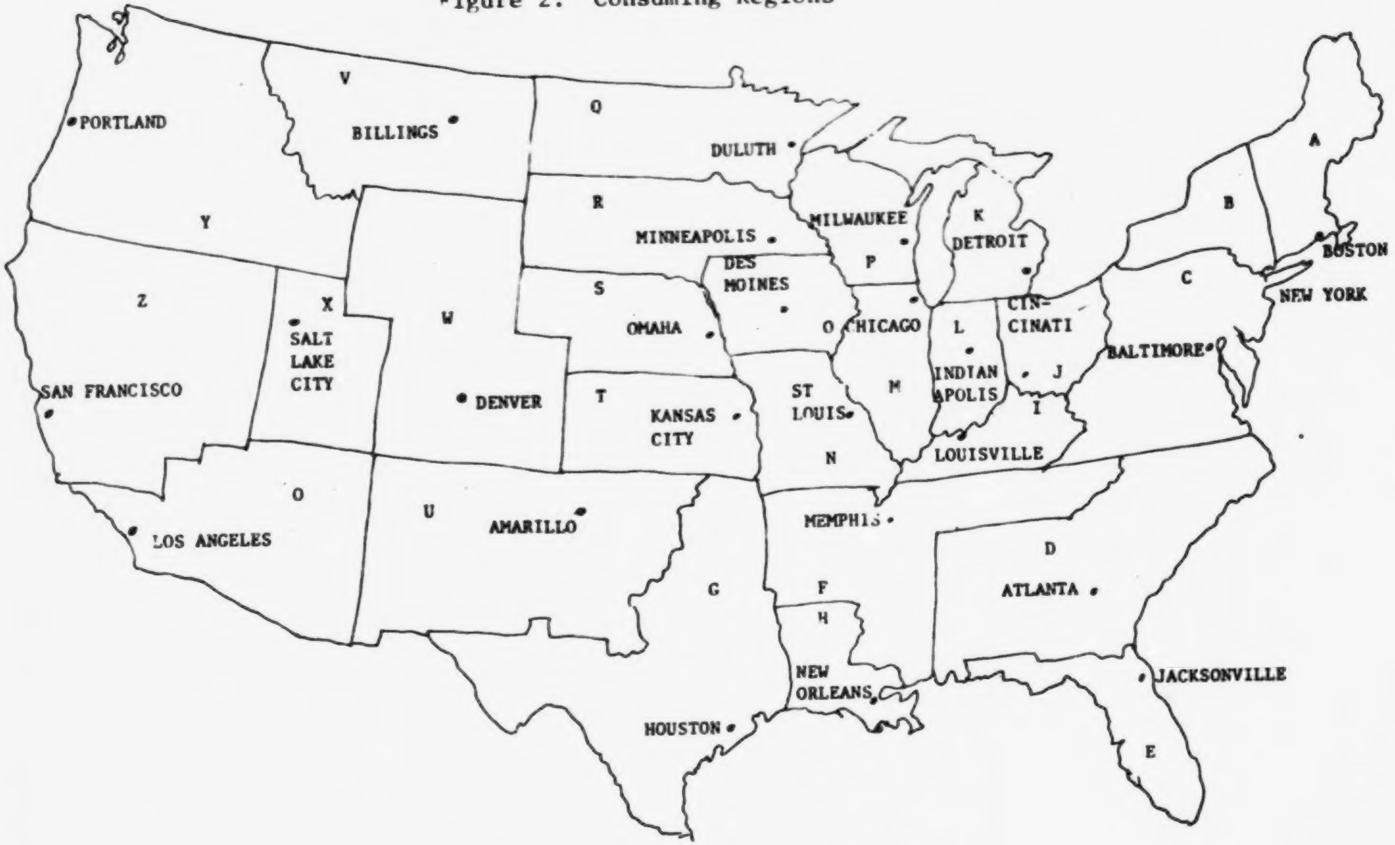
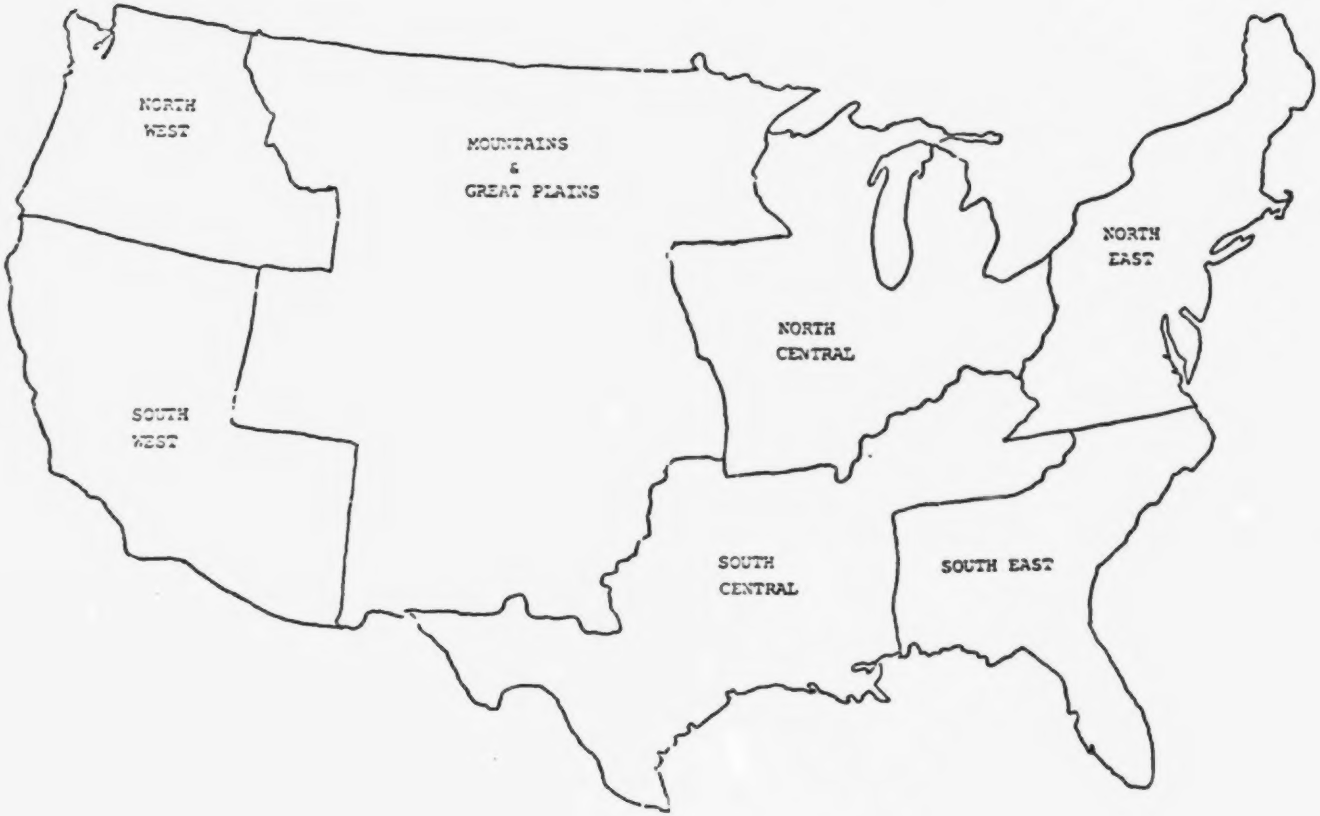


Figure 3. Major Regions.



analysis guarantees that the dual solution of a cost minimization model is a profit maximizing solution; therefore, the activity levels for both cases are identical. The cost minimization formulation was chosen on the basis of modeling criteria which does not affect the accuracy or validity of the solution.

Pesticide Analysis - A Special Case of the General Agricultural Model

To be useful for pesticide policy analysis, the solution to the model must depict impacts within a short-run period (a five-year time horizon). Due to the dynamics of pest control which include development of resistant pests and new technology, projections and simulations of impacts extending far into the future are futile. Therefore, the data base used in the LP model is constructed for a typical year in the 1975-1980 time period. This particular time frame provides an opportunity to analyze the short-run effects of pesticide policies. Unlike many other national models which have been constructed, the EPA model permits examination of immediate adjustments rather than the eventual long-run equilibrium position of agriculture.

An important criterion for a short-run model is that it generates solutions which are believable. The base model must closely coincide with current agricultural production (both crop mix and spatially) and current pesticide use patterns. However, the real world agricultural sector is not always optimal in the sense of "most efficient" allocation of resources to minimize or maximize an objective function. Therefore, the previously mentioned flexibility penalties were introduced into the model in an attempt to account for non-optimalities. Penalties are added to production cost as the acreage of any crop increases significantly over the historical trend. One purpose of these penalties is to reflect the cost of change -- the implementation of new inputs, the change-over to new machinery, and risk aversion. Secondly, the flexibility penalties reflect the insensitivity of farmers to minor price incentives which otherwise might shift production patterns within the model. The benefit of using such penalties, which are unique to the EPA model, is that the model more accurately reflects the observed stability of the real world.

Application to Chlordane/Heptachlor Suspension

Two formulations of the base model have been used to evaluate the impact of suspension. The first evaluation was made under the assumptions of extreme yield loss and incorporated a base model which was disaggregated by nine soil classes. The second evaluation assumed less extreme yield impacts and included a reformulation of the land base into three soil groups. The reformulation was made to reduce the size of the model in order to reduce solution costs after examination and evaluation of the model in its two formulations.

To evaluate the impact of restricting the use of chlordane and heptachlor, the land base in corn growing regions had to be disaggregated by insect infestation. Infestations were further disaggregated by soil productivity class to enable interaction between the yields associated with various soils and crop loss due to infestations. Base model solutions for treated corn acreage (as opposed to infested crop acreage) are reported in Table 1 (for the extreme case analysis and Table 2 for the typical analysis). As these tables indicate, chlorinated hydrocarbon insecticides are the primary control agent on cutworm infested land while other insecticides in addition to chlorinated hydrocarbon insecticides are used to control rootworms and wireworms.

Evaluation of the impact of restricting the use of C/H requires a system of comparative statics where the solution in the base model which allows C/H use is compared to the solution of a second model with C/H use options excluded from the feasible set of production activities. To accomplish this, several assumptions were required to define the parameters for specification of the second model.

Explicit assumptions in the chlorinated hydrocarbon exclusion models included the areas treated with C/H during the base year (1977) and yield impacts associated with C/H withdrawal. In both cases, the assumption was made that following the recent aldrin/dieldrin suspension, C/H would fill the void created by other chlorinated hydrocarbon withdrawals. Therefore, the expected use of C/H could be simulated by examining the most recent estimates of total aldrin, dieldrin, chlordane and heptachlor use on corn. To the extent that other chemicals in addition to C/H fill the void created by restrictions in aldrin and dieldrin, the models over-estimate C/H use and therefore over-estimate derived benefits from C/H use (costs associated with cancellation). Yield inputs for the extreme case analysis, with the exception of those associated with rootworm treatment, were assumed to be at the level reported by Delvo. Delvo did not specify yield impacts on

Table 1. Base model distribution of corn acreage infested by wireworm, rootworm and cutworm by treatment option.

State	No Treatment	Other Pesticides	Chlorinated Hydrocarbon
	-----------------millions of acres-----------------		
Ohio			
Wireworm	0	0	.17
Rootworm	.03	0	.39
Cutworm	.12	0	.16
Total	.15	0	.72
Michigan			
Wireworm	.23	.13	.25
Rootworm	0	0	0
Cutworm	0	0	0
Total	.23	.13	.25
Indiana			
Wireworm	.05	.01	.28
Rootworm	.61	.07	.72
Cutworm	0	0	.36
Total	.66	.08	1.36
Illinois			
Wireworm	.1	.37	.49
Rootworm	.09	.93	1.0
Cutworm	.03	.03	.83
Total	.22	1.33	2.32
Missouri			
Wireworm	.03	.07	.11
Rootworm	.06	.18	.14
Cutworm	0	0	.45
Total	.09	.25	.70
Iowa			
Wireworm	.04	.26	.11
Rootworm	.01	2.33	.71
Cutworm	0	0	.54
Total	.05	2.59	1.36
Wisconsin			
Wireworm	0	0	0
Rootworm	.21	.77	0
Cutworm	.02	0	0
Total	.23	.77	0

Table 1 (Continued).

State	No Treatment	Other Pesticides	Chlorinated Hydrocarbon
Minnesota (N)			
Wireworm	0	.01	0
Rootworm	0	.08	0
Cutworm	0	0	.01
Total	0	.09	.01
Minnesota (S)			
Wireworm	.13	.13	.02
Rootworm	.11	1.15	.07
Cutworm	.23	0	.12
Total	.47	1.28	.21
Nebraska			
Wireworm	0	0	0
Rootworm	.16	2.26	.02
Cutworm	.06	0	.09
Total	.22	2.26	.11
Kansas			
Wireworm	.04	.05	0
Rootworm	.02	.21	0
Cutworm	.05	0	.04
Total	.11	.26	.04
Total	2.53	9.07	7.12

Table Note: Individual columns may not total due to rounding error.

Table 2. Base model distribution of corn acreage infested by wireworms, rootworms and cutworms by treatment options, typical case assumptions.

CHICAGO
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO. INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	67.59	525.08	.	.	592.67
ROOT	WORM	345.48	1311.28	.	.	1656.76
CUT	WORM	786.67	.	.	.	786.67
UNSPEC	INFESTN	1260.74	786.90	4616.26	.	6663.90
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	2460.48	2623.26	4616.26	.	9700.00

CINCINNATI
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	24.37	48.89	.	.	73.26
ROOT	WORM	113.35	65.23	.	.	178.58
CUT	WORM	58.05	.	.	.	58.05
UNSPEC	INFESTN	305.14	51.62	1673.89	.	2030.65
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	500.91	165.74	1673.89	.	2340.54

DETROIT
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	13.72	.	.	.	13.72
ROOT	WORM	6.07	25.39	25.75	.	57.22
CUT	WORM	17.96	.	.	.	17.96
UNSPEC	INFESTN	28.57	33.14	282.20	.	343.91
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	66.32	58.54	307.95	.	432.81

Table 2 (Continued).

```
DULUTH
 --- 000 ACRES ---

                     C/H          OTHER      NO          OTHER      TOTAL
                     A/D          INSICIDE   INSICIDE    TREATMT    CORN

WIRE      WORM            2.86       1.79        0.39         .        5.04
ROOT      WORM              .       76.53          .          .       76.53
CUT       WORM            6.28       0.77          .          .        7.05
UNSPEC    INFESTN           .       15.56      192.22         .      207.78
OTHER     LAND              .          .           .          .          .
TOTAL     CORN            9.14      94.65      192.61         .      296.41


INDIANIAPOLIS
 --- 000 ACRES ---

                     C/H          OTHER      NO          OTHER      TOTAL
                     A/D          INSICIDE   INSICIDE    TREATMT    CORN

WIRE      WORM           13.91     135.80          .          .      149.71
ROOT      WORM          298.86     151.78          .          .      450.63
CUT       WORM          245.29        .            .          .      245.29
UNSPEC    INFESTN       621.44     191.37     3399.18         .     4211.99
OTHER     LAND              .         .            .          .          .
TOTAL     CORN         1179.50     478.94     3399.18         .     5057.62


KANSAS CITY
 --- 000 ACRES ---

                     C/H          OTHER      NO          OTHER      TOTAL
                     A/D          INSICIDE   INSICIDE    TREATMT    CORN

WIRE      WORM            7.63        .         34.48         .       42.10
ROOT      WORM              .      481.46          .          .      481.46
CUT       WORM           58.07      10.35          .          .       68.42
UNSPEC    INFESTN         1.74       7.08     1096.87         .     1105.69
OTHER     LAND              .         .            .          .          .
TOTAL     CORN           67.44     498.88     1131.35         .     1697.67
```

Table 2 (Continued).

MILWAUKEE
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	.	.	.	.
ROOT	WORM	0,79	462,92	.	.	463,71
CUT	WORM	14,99	.	.	.	14,99
UNSPEC	INFESTN	85,64	537,62	1103,04	.	1726,30
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	101,43	1000,54	1103,04	.	2205,01

MINNEAPOLIS
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	44,03	28,62	0,75	.	73,40
ROOT	WORM	.	1153,75	.	.	1153,75
CUT	WORM	87,69	13,63	.	.	101,32
UNSPEC	INFESTN	97,59	411,66	2665,58	.	3174,85
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	229,31	1607,69	2666,34	.	4503,33

OMAHA
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	.	.	.	.
ROOT	WORM	59,37	2113,72	.	.	2173,08
CUT	WORM	61,46	.	.	.	61,46
UNSPEC	INFESTN	119,64	875,13	1687,16	.	2681,94
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	240,46	2988,85	1687,16	.	4916,48

Table 2 (Continued).

ST. LOUIS
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	190.16	.	.	.	190.16
ROOT	WORM	250.87	141.25	.	.	392.12
CUT	WORM	270.78	.	.	.	270.78
UNSPEC	INFESTN	293.14	211.22	1451.46	.	1955.82
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	1004.95	352.47	1451.46	.	2808.88

----------1.>. TOTAL CORN TREATMENTS-----------

--- 000 ACRES ---

		C/H A/D.	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	624.57	740.17	35.62	.	1400.37
ROOT	WORM	1484.70	8552.19	25.75	.	10062.64
CUT	WORM	2069.74	24.75	.	.	2094.49
UNSPEC	INFESTN	3143.01	3308.47	21910.17	.	28361.65
OTHER	LAND	.	.	.	11637.65	11637.65
TOTAL	CORN	7322.02	12625.59	21971.55	11637.65	53556.81

rootworm treated land other than to assume "that corn yield would not change if alternative insecticides were used to replace aldrin for corn rootworm control" (p. 6). He further stated that "there is some indication, from Illinois data, that yields may increase if nonorganochlorine insecticides are substituted for aldrin in corn rootworm control" (p. 6). Further examination of this issue by entomologists in C&E Division indicated that, due to widespread rootworm resistance to organochlorines, the increased yields associated with shifting from organochlorines to other pesticides may be significant and not unique to Illinois. As a starting point, the parameters for rootworm damage in the restrictive model specify a 15 percent yield decline if no insecticides are used to replace chlorinated hydrocarbons on previously treated rootworm land and an 8 percent yield decline if C/H is used in place of other pesticides. In other words, it was assumed that the use of other pesticides would produce the average projected state yields while the use of C/H would lead to 8 percent yield declines on rootworm infested acreage. The full yield file is reported in Table 3. The yield impact estimates for the typical year analysis are reported in Table 4.

Solution Impacts, Typical Case Assumptions

On a national basis, comparison of the model solutions with and without organochlorines shows an increase in planted acres of 35,708 acres (Table 5). This was distributed among crops as an increase in corn acreage of 88,288, an increase of cotton acreage of 566 acres, an increase of barley equalling 2,937 acres, an increase in wheat acreage of 1,742 acres, a decrease in soybean

Table 3. Impact of restriction in chlorinated hydrocarbon insecticide use by species

State	species:	Cutworm		Wireworm		Rootworm	
	option:	w/alt.*	w/o alt.*	w/alt.	w/o alt.	w/alt	w/o alt.
		----------------percent change from state yeild					
Ohio		-5	-10	0	-10	0	-15
Indiana		-10	-25	0	-10	0	-15
Illinois		-10	-25	0	-10	0	-15
Iowa		-10	-25	-8	-12	0	-15
Missouri		-15	-30	-8	-12	0	-15
Lake States & Northern Plains		-10	-25	-8	-12	0	-15

*w/alt. = with alternative pesticides.
w/o alt. = without alternative pesticides.

Table 4. Estimated impact on average yields of alternative insecticide options, by state/regions, U.S., 1975-80

States	With alternatives			Without alternatives			With chlordane, heptachlor, aldrin		
	Rootworm	Wireworm	Cutworm	Rootworm	Wireworm	Cutworm	Rootworm	Wireworm	Cutworm
	----- Percent -----								
EPA Estimates									
Ohio	0	0	-2.0	-7.8	-3.9	-3.9	-3.9	0	0
Indiana	0	0	-3.9	-7.8	-3.9	-9.8	-3.9	0	0
Illinois	0	0	-3.5	-6.4	-3.5	-8.7	-3.2	0	0
Iowa	0	-3.6	-4.5	-9.1	-5.4	-11.2	-4.5	0	0
Missouri	0	-3.1	-5.9	-7.8	-4.7	-11.7	-3.9	0	0
Lake States and N. Plains	0	-3.1	-3.9	-7.8	-4.7	-9.8	-3.9	0	0
Other states	0	0	0	0	0	0	0	0	0
Delvo Estimates									
Ohio	0	0	-5.0	0	-10.0	-10.0	0	0	0
Indiana	0	0	-10.0	0	-10.0	-25.0	0	0	0
Illinois	0	0	-10.0	0	-10.0	-25.0	0	0	0
Iowa	0	-8.0	-10.0	0	-12.0	-25.0	0	0	0
Missouri	0	-8.0	-15.0	0	-12.0	-30.0	0	0	0
Lake States and N. Plains	0	-8.0	-10.0	0	-12.0	-25.0	0	0	0
Other states	0	0	0	0	0	0	0	0	0

Sources: EPA Estimates: USDA/ERS - 557 and long term studies in Iowa (Peters, 1975) and Illinois (Bigger and Decker, 1966).
Delvo Estimates: USDA/ERS report no. 557, June 1974, by Herman Delvo.

Table 5.

ENVIRONMENTAL PROTECTION AGENCY - CORN MODEL

INTERCASE RESULT COMPARISON FOR

LAND UTILIZATION: USE

		1	2	3	TOTAL
		------1,000 acres			
BOSTON	A	.	.	.	.
NEW YORK	B	.	.	.	.
BATLIMORE	C	.	.	.	.
ATLANTA	D	.	.	.	.
JACKSONVILLE	E	.	.	.	.
MEMPHIS	F	.	.	0,000	0,000
HOUSTON	G	-32,610	-63,656	96,266	0,000
NEW ORLEANS	H	.	0,000	-0,000	0,000
LOUISVILLE	I	.	.	.	.
CINCINNATI	J	-138,565	106,624	31,941	0,000
DETROIT	K	-33,503	33,503	.	-0,000
INDIANIAPOLIS	L	-0,001	.	0,001	0,000
CHICAGO	M	.	.	.	.
ST. LOUIS	N	.	.	.	.
DES MOINES	O	-199,721	117,693	82,028	0,000
MILWAUKEE	P	.	.	.	.
DULUTH	Q	-0,371	-12,739	-5,611	-18,721
MINNEAPOLIS	R	41,623	43,358	-14,783	70,198
OMAHA	S	.	-0,000	0,000	0,000
KANSAS CITY	T	-15,346	.	.	-15,346
AMARILLO	U	.	.	0,395	0,395
BILLINGS	V	.	.	.	.
DENVER	W	.	-0,887	0,887	-0,000
SALT LAKE CITY	X	.	.	.	.
PORTLAND	Y	.	.	.	.
SAN FRANCISCO	Z	.	.	.	.
LOS ANGELES	0	25,959	-26,184	-0,594	-0,818
*** TOTAL ***		-352,535	197,712	190,530	35,708

acreage of 49,027 acres and a decrease in grain sorghum of 8,798 acres. Regional changes in corn acreage planted for grain which result from the organochlorine restriction are reported in Table 6. The corresponding changes in total corn production (an increase of 199,986 bushels) are reported in Table 7.

Several measures of impact on farm income can be derived from the results of the comparative analyses. One proxy measure for economic profit from agricultural activity is the residual return to land. For all crops in the model, the restriction in the use of organochlorines caused an increase in returns to land of $3.12 million or 0.08 percent (Tables 8 and 9). Changes in land rent derived from corn production were decreased by $6.1 million (Tables 10 and 11). Residual return over production expenses including labor for all agricultural activity within the model is decreased slightly as a result of excluding organochlorines by $8.52 million (Tables 9 and 10). For corn production, residual return increased slightly by $0.52 million or by 0.02 percent (Table 10).

Production expenses to meet demand for the seven crops increased by $6.38 million or by 0.06 percent (Table 9). For corn the increase was $9.69 million or 0.23 percent (Table 11).

Changes in the various indicators of income and cost were more significant at the regional level, but generally not indicative of major economic impacts (Tables 9 and 11).

Table 6.

ENVIRONMENTAL PROTECTION AGENCY - CORN MODEL

INTERCASE RESULT COMPARISON FOR

CROP ACRES: CORN

		UNSPECFD	GROUP1	GROUP2	GROUP3	TOTAL
		-----------------1,000 acres-----------------				
BOSTON	A	.	.	.	.	.
NEW YORK	B	.	.	.	.	.
BATLIMORE	C	.	.	.	.	.
ATLANTA	D	.	.	0.526	.	0.526
JACKSONVILLE	E	.	140.482	.	.	140.482
MEMPHIS	F	.	.	.	.	.
HOUSTON	G	.	-9.545	.	9.545	-0.000
NEW ORLEANS	H	.	.	.	.	.
LOUISVILLE	I	.	.	.	.	.
CINCINNATI	J	.	.	.	.	.
DETROIT	K	.	-131.725	80.802	50.923	-0.000
INDIANIAPOLIS	L	.	-33.503	33.503	-0.000	-0.000
CHICAGO	M	.	0.000	-0.000	-0.000	-0.000
ST. LOUIS	N	.	-84.836	0.000	-0.002	-84.838
DES MOINES	O	.	-0.000	-0.000	-0.000	-0.000
MILWAUKEE	P	.	-199.719	117.689	82.030	-0.000
DULUTH	Q	.	0.000	0.000	0.000	0.000
MINNEAPOLIS	R	.	-3.284	-28.678	-6.487	-38.449
OMAHA	S	.	-0.762	101.459	-14.783	85.914
KANSAS CITY	T	.	0.000	-0.000	0.000	0.000
AMARILLO	U	.	-15.346	-0.000	-0.000	-15.346
BILLINGS	V	.	.	.	.	.
DENVER	W	.	.	.	.	.
SALT LAKE CITY	X	.	.	-0.887	0.887	.
PORTLAND	Y	.	.	.	.	.
SAN FRANCISCO	Z	.	.	.	.	.
LOS ANGELES	0	.	.	.	.	.
*** TOTAL ***		.	-338.239	304.414	122.113	88.288

Table 7.

ENVIRONMENTAL PROTECTION AGENCY - CORN MODEL

INTERCASE RESULT COMPARISON FOR

COMMODITY QUANTITIES: CORN

		-----------------------------	-----------------------------	-----1,000 bushels-----	-----------------------------	-----------------------------
		REGIONAL PRODUCTN	REGIONAL CMDY.USE	REGIONAL FEEDING	EXPT.NET REGIONAL	EXPT.NET NATIONAL
BOSTON	A	.	.	.	.	.
NEW YORK	B	.	.	.	.	.
BALTIMORE	C	40,426	.	40,426	.	.
ATLANTA	D	10289,375	.	3326,700	6962,675	.
JACKSONVILLE	E	.	.	.	.	.
MEMPHIS	F	0,000	.	-3097,755	3097,755	.
HOUSTON	G	.	.	-0,243	0,243	.
NEW ORLEANS	H	-0,000	.	.	-0,000	.
LOUISVILLE	I	.	.	.	.	.
CINCINNATI	J	114,699	.	-18,328	133,027	.
DETROIT	K	-66,637	.	.	-66,637	.
INDIANIAPOLIS	L	220,956	.	.	220,956	.
CHICAGO	M	-11889,545	.	.	-11889,545	.
ST. LOUIS	N	-1281,465	.	.	-1281,465	.
DES MOINES	O	-1736,745	.	.	-1736,745	.
MILWAUKEE	P	-53,755	.	.	-53,755	.
DULUTH	Q	-2126,505	.	.	-2103,460	-23,045
MINNEAPOLIS	R	8533,241	.	.	8533,241	.
OMAHA	S	-38,072	.	.	-38,072	.
KANSAS CITY	T	-1805,986	.	.	-1805,986	.
AMARILLO	U	.	.	.	.	.
BILLINGS	V	.	.	-28,012	28,012	.
DENVER	W	0,000	.	.	0,000	.
SALT LAKE CITY	X	.	.	.	.	.
PORTLAND	Y	.	.	.	.	.
SAN FRANCISCO	Z	.	.	.	.	.
LOS ANGELES	0	-0,000	.	0,244	-0,244	.
***TOTAL ***		199,986	.	223,031	.	-23,045

Table 8. Income components for base (unrestricted) and suspension (restricted) solutions, seven crops, U.S. by region, 1977

Base solution ($ million)

```
------ REGIONAL INCOME COMPONENTS - ALL CROPS ----
 $ MILLION

                          LAND     ECONOMIC   ECONOMIC   RESIDUAL    PRODTN      TOTAL
                          RENT     PROFITS    LOSSES     RETURNS     EXPENSES    SALES

BOSTON                      .         2,20        .          2,20        .           2,20
NEW YORK                  20,05      10,13      -1,42       28,76      35,17       63,93
BALTIMORE                162,00     101,23     -20,50      243,31     317,09      560,40
ATLANTA                   35,74     110,47     -60,54       85,67     645,74      731,41
JACKSONVILLE                .         8,16      -9,62       -1,46      49,30       47,84
MEMPHIS                  131,95      65,37    -149,70       47,62     821,67      869,29
HOUSTON                   47,55     349,05     -13,72      382,88     558,29      941,17
NEW ORLEANS                 .        10,34      -4,10        6,24     140,70      146,94
LOUISVILLE                64,83      15,67     -34,76       45,74     101,31      147,05
CINCINNATI               154,50     136,33     -61,20      229,63     311,14      540,77
DETROIT                     .        79,12      -0,32       78,80      93,26      172,06
INDIANAPOLIS             362,75     169,00    -118,10      413,65     505,27      918,92
CHICAGO                  753,75     343,67    -265,88      831,54    1139,45     1970,99
ST. LOUIS                145,07      99,73    -102,63      142,17     653,35      795,52
DES MOINES                  .       547,43      -0,00      547,43    1044,79     1592,22
MILWAUKEE                  6,17     158,36      -1,05      163,48     176,82      340,30
DULUTH                   347,22     395,04     -17,20      725,06     314,88     1039,94
MINNEAPOLIS              152,83     394,50     -13,30      534,03     515,47     1049,50
OMAHA                    418,79     393,55    -232,63      579,71     539,23     1118,94
KANSAS CITY              595,83     465,31     -36,84     1024,30     504,56     1528,86
AMARILLO                 262,23     665,62     -34,43      893,42     769,31     1662,73
BILLINGS                  92,94     142,11      -8,44      226,61     116,85      343,46
DENVER                    26,35     229,09      -0,04      255,40      85,95      341,35
SALT LAKE CITY              .        30,15        .         30,15        .          30,15
PORTLAND                 250,70     456,44     -27,13      680,01     176,31      856,32
SAN FRANCISCO             49,16     116,36      -0,95      164,57     367,23      531,80
LOS ANGELES               16,04      53,11     -12,39       56,76     122,38      179,14
**TOTAL*                4169,30    5544,53   -1256,74     8457,09   10004,44    18461,53
```

Suspension ($ million)

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------ REGIONAL INCOME COMPONENTS - ALL CROPS ----
 $ MILLION

                          LAND     ECONOMIC   ECONOMIC   RESIDUAL    PRODTN      TOTAL
                          RENT     PROFITS    LOSSES     RETURNS     EXPENSES    SALES

BOSTON                      .         2,24        .          2,24        .           2,24
NEW YORK                  20,20      10,13      -3,42       26,91      35,17       62,08
BALTIMORE                162,91     101,36     -20,09      244,18     317,11      561,29
ATLANTA                   35,54     114,56     -78,43       71,67     649,38      721,05
JACKSONVILLE                .         8,14      -9,60       -1,46      49,30       47,84
MEMPHIS                  131,16      63,53    -132,77       61,92     821,67      883,59
HOUSTON                   47,55     349,47     -13,72      383,30     558,29      941,59
NEW ORLEANS                 .        10,44      -4,30        6,14     140,70      146,84
LOUISVILLE                64,86      15,06     -34,75       45,17     101,31      146,48
CINCINNATI               154,95     137,36     -61,57      230,74     311,24      541,98
DETROIT                     .        78,92      -0,80       78,12      93,33      171,45
INDIANAPOLIS             361,81     191,11    -118,15      434,77     505,31      940,08
CHICAGO                  750,35     311,17    -238,62      822,90    1139,40     1962,30
ST. LOUIS                147,44     123,34    -165,90      104,88     653,11      757,99
DES MOINES                  .       545,47      -0,04      545,43    1044,47     1589,90
MILWAUKEE                  6,10     158,54      -1,05      163,59     176,81      340,40
DULUTH                   340,67     394,76     -18,59      716,84     314,90     1031,74
MINNEAPOLIS              167,21     376,71     -18,07      525,85     515,54     1041,39
OMAHA                    417,13     374,95    -213,37      578,71     539,74     1118,45
KANSAS CITY              595,14     463,49     -37,18     1021,45     504,53     1525,98
AMARILLO                 260,43     665,75     -34,51      891,67     769,44     1661,11
BILLINGS                  93,05     141,36      -8,42      225,99     116,91      342,90
DENVER                    26,42     229,61      -0,14      255,89      85,95      341,84
SALT LAKE CITY              .        30,15        .         30,15        .          30,15
PORTLAND                 251,47     455,41     -27,07      679,81     176,31      856,12
SAN FRANCISCO             49,10     116,17      -1,01      164,26     367,23      531,49
LOS ANGELES                9,60      55,50     -12,34       52,76     167,45      220,21
**TOTAL*                4112,53    5530,84   -1274,67     8368,67   10012,87    18381,54
```

Table 9. Changes in income components with suspension, seven crops, changes $ million and percent, U.S., by region. 1977

INTER CASE RESULT COMPARISON TABLES

INCOME COMPONENTS--ALL CROPS

VALUE OF FIRST DIFFERENCES

Change in $ million

	LAND RENT	ECONOMIC PROFITS	ECONOMIC LOSSES	RESIDUAL RETURNS	PRODCTN EXPENSES	TOTAL SALES
BOSTON	*	0.04	*	0.04	*	0.04
NEW YORK	0.06	-0.01	0.06	0.01	*	0.01
BALTIMORE	0.31	0.07	-0.16	0.23	0.02	0.36
ATLANTA	-0.24	4.03	2.13	5.46	3.04	9.02
JACKSONVILLE	*	0.06	-0.04	-0.01	0.00	-0.01
MEMPHIS	-0.05	0.18	-0.07	-0.75	0.00	-0.75
HOUSTON	0.16	0.16	0.04	0.24	*	0.26
NEW ORLEANS	*	0.04	-0.10	-0.13	*	-0.13
LOUISVILLE	-2.22	0.15	-0.04	-0.17	*	-0.07
CINCINNATI	0.34	0.44	-0.49	0.04	-0.80	0.63
DETROIT	*	-0.24	-0.01	-0.26	-0.02	-0.23
INDIANAPOLIS	-0.94	1.46	0.01	0.47	0.04	0.53
CHICAGO	-3.46	7.71	-16.94	-6.05	-3.97	-10.06
ST. LOUIS	-3.05	3.37	-1.13	-1.44	-0.24	-1.04
DES MOINES	*	-1.40	-0.04	-1.45	-0.32	-1.76
MILWAUKEE	0.01	0.24	0.04	0.24	-0.01	0.23
DULUTH	-1.55	-0.57	-1.28	-5.03	0.07	-8.42
MINNEAPOLIS	14.16	-7.77	-4.77	1.06	8.16	9.74
OMAHA	-0.47	1.41	-0.54	0.30	-0.03	0.35
KANSAS CITY	-0.64	-2.26	-0.35	-3.20	-0.07	-3.35
AMARILLO	0.26	0.13	-0.07	0.20	0.05	0.34
BILLINGS	0.06	-0.43	-0.06	-0.54	0.00	-0.53
DENVER	0.07	-0.20	0.04	-0.21	*	-0.21
SALT LAKE CITY	*	-0.06	*	-0.04	*	-0.06
PORTLAND	-0.31	-0.14	0.16	-0.15	*	-0.04
SAN FRANCISCO	0.02	-0.13	0.00	-0.11	*	-0.11
LOS ANGELES	-0.13	-0.60	2.05	-0.17	-0.15	-0.32
**TOTAL*	3.12	0.24	-17.95	-8.52	0.35	-2.14

****COMPARE OUTPUT WITH CORN HI****

INTER CASE RESULT COMPARISON TABLES

INCOME COMPONENTS--ALL CROPS

PERCENT DIFFERENCES

change in percent

	LAND RENT	ECONOMIC PROFITS	ECONOMIC LOSSES	RESIDUAL RETURNS	PRODCTN EXPENSES	TOTAL SALES
BOSTON	*	0.00	*	0.00	*	0.00
NEW YORK	0.08	-0.24	-0.01	0.03	*	0.01
BALTIMORE	0.36	0.04	0.40	0.12	0.01	0.05
ATLANTA	-0.57	5.05	-2.07	9.11	0.56	1.35
JACKSONVILLE	*	0.36	0.45	0.71	0.00	-0.04
MEMPHIS	-0.04	0.24	0.04	-5.55	0.00	-0.14
HOUSTON	0.36	0.05	-0.01	0.02	*	0.04
NEW ORLEANS	*	0.03	4.55	-3.54	*	-0.14
LOUISVILLE	-0.32	0.47	0.24	-0.15	*	-0.05
CINCINNATI	0.25	0.73	0.81	0.34	-0.20	0.01
DETROIT	*	-0.40	30.25	-0.27	-0.02	-0.13
INDIANAPOLIS	-0.26	0.75	-0.01	0.31	0.01	0.05
CHICAGO	-0.45	2.54	4.05	-0.06	-0.35	-0.54
ST. LOUIS	-1.09	5.50	1.16	-0.74	-0.05	-0.25
DES MOINES	*	-0.27	2.77	-0.07	-0.03	-0.11
MILWAUKEE	0.16	0.15	-0.11	0.13	-0.01	0.77
DULUTH	-0.34	-0.11	7.42	-0.44	0.02	-0.70
MINNEAPOLIS	4.26	-2.02	35.00	0.51	1.50	0.46
OMAHA	-0.11	0.30	0.25	0.04	-0.04	0.03
KANSAS CITY	-0.16	-0.40	0.94	-0.36	-0.01	-0.02
AMARILLO	0.00	0.04	0.14	2.03	0.01	0.06
BILLINGS	0.16	-0.44	0.20	-0.20	0.05	-0.13
DENVER	0.27	-0.12	-5.00	-0.00	*	-0.06
SALT LAKE CITY	*	-0.00	*	-0.00	*	-0.30
PORTLAND	-0.12	-0.13	-0.23	-0.16	*	-0.16
SAN FRANCISCO	0.04	-0.11	-0.25	-0.00	*	-0.76
LOS ANGELES	-1.33	-0.10	-0.37	-0.51	-0.16	-0.10
**TOTAL*	0.00	0.11	1.43	-0.16	0.00	-0.01

Table 10. Income components for base solution and suspension, corn grain, U.S. by region, 1977.

****** REGIONAL INCOME COMPONENTS BY CROP*******
CORN GRAIN
$ MILLION

Base solution ($ million)

	LAND RENT	ECONOMIC PROFITS	ECONOMIC LOSSES	RESIDUAL RETURNS	PRODTN EXPENSES	TOTAL SALES
BOSTON	.	.	.	.	.	.
NEW YORK	9.27	0.75	-0.00	10.02	24.44	34.46
BALTIMORE	62.26	129.70	.	191.96	224.28	416.24
ATLANTA	15.47	88.16	-0.00	103.63	235.23	338.86
JACKSONVILLE	.	3.56	.	3.56	22.60	26.16
MEMPHIS	4.17	15.64	.	19.81	40.00	59.81
HOUSTON	0.47	113.84	.	114.31	96.13	210.44
NEW ORLEANS	.	8.67	.	8.67	.	8.67
LOUISVILLE	20.94	14.15	.	35.09	43.78	78.87
CINCINNATI	66.30	62.71	.	129.01	155.71	284.72
DETROIT	.	21.40	.	21.40	26.99	48.39
INDIANAPOLIS	192.27	152.31	.	344.58	381.07	725.65
CHICAGO	381.35	254.42	-0.00	635.77	786.97	1422.74
ST. LOUIS	68.36	54.53	-0.33	122.55	228.53	351.07
DES MOINES	.	441.05	.	441.05	726.72	1167.77
MILWAUKEE	4.13	147.24	.	151.37	149.94	301.31
DULUTH	2.73	15.07	-0.20	17.60	10.78	28.38
MINNEAPOLIS	37.85	167.83	.	205.68	258.11	463.79
OMAHA	358.20	104.87	-230.57	232.50	416.16	648.66
KANSAS CITY	44.21	63.84	-5.21	102.84	156.87	259.70
AMARILLO	25.93	190.00	-0.01	215.92	139.65	355.57
BILLINGS	0.03	0.89	.	0.92	.	0.92
DENVER	2.74	43.60	.	46.34	32.31	78.65
SALT LAKE CITY	.	1.97	.	1.97	.	1.97
PORTLAND	0.06	17.36	.	17.42	7.50	24.92
SAN FRANCISCO	8.19	26.73	.	34.92	24.33	59.25
LOS ANGELES	.	.	.	.	.	.
**TOTALS*	1284.86	2160.64	-236.33	3209.17	4188.08	7397.25

Suspension ($ million)

****** REGIONAL INCOME COMPONENTS BY CROP*******
CORN GRAIN
$ MILLION

	LAND RENT	ECONOMIC PROFITS	ECONOMIC LOSSES	RESIDUAL RETURNS	PRODTN EXPENSES	TOTAL SALES
BOSTON	.	.	.	.	.	.
NEW YORK	9.28	0.77	-0.00	10.05	24.44	34.49
BALTIMORE	62.48	129.93	.	192.40	224.32	416.72
ATLANTA	16.44	92.19	-0.00	108.63	245.22	353.84
JACKSONVILLE	.	3.52	.	3.52	22.60	26.12
MEMPHIS	4.14	15.73	.	19.87	40.00	59.87
HOUSTON	0.47	114.04	.	114.51	96.13	210.65
NEW ORLEANS	.	8.86	.	8.86	.	8.86
LOUISVILLE	20.87	14.30	.	35.17	43.78	78.95
CINCINNATI	66.42	63.93	.	130.35	154.85	285.20
DETROIT	.	21.43	.	21.43	26.91	48.34
INDIANAPOLIS	191.70	153.90	.	345.60	381.11	726.71
CHICAGO	375.39	262.24	-8.24	629.39	779.85	1409.24
ST. LOUIS	66.96	57.60	-2.96	121.60	228.30	349.90
DES MOINES	.	440.77	.	440.77	726.40	1167.17
MILWAUKEE	4.18	147.44	.	151.62	149.93	301.55
DULUTH	2.07	14.10	-1.59	14.58	10.77	25.35
MINNEAPOLIS	39.36	169.41	.	208.78	266.36	475.14
OMAHA	358.10	106.42	-231.16	233.36	416.16	649.52
KANSAS CITY	43.99	62.47	-5.43	101.04	156.79	257.83
AMARILLO	25.95	190.39	-0.02	216.32	139.65	355.97
BILLINGS	0.03	0.89	.	0.92	.	0.92
DENVER	2.69	43.73	.	46.42	32.31	78.73
SALT LAKE CITY	.	1.97	.	1.97	.	1.97
PORTLAND	0.04	17.40	.	17.44	7.50	24.94
SAN FRANCISCO	8.19	26.78	.	34.97	24.33	59.30
LOS ANGELES	.	.	.	.	.	.
**TOTALS*	1298.75	2160.34	-249.40	3209.69	4197.71	7407.40

Table 11. Change in income components with suspension, corn grain, U.S. by region, 1977.

Change in $ million

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INTER CASE RESULT COMPARISON TABLES

INCOME COMPONENTS--CORN

VALUE OF FIRST DIFFERENCES

                      LAND      ECONOMIC   ECONOMIC   RESIDUAL   PRODCTN    TOTAL
                      RENT      PROFITS    LOSSES     RETURNS    EXPENSES   SALES

BOSTON                  .          .          .          .          .          .
NEW YORK              0,01       0,03       0,00       0,01         .        0,03
BALTIMORE             0,21       0,22         .        0,41       0,04       0,40
ATLANTA               0,97       4,05       0,06       4,97       9,44      14,90
JACKSONVILLE            .        0,03         .        0,01         .        0,03
MEMPHIS              -0,03       0,09         .        0,07      -0,00       0,07
HOUSTON               0,06       0,21         .        0,21         .        0,21
NEW ORLEANS             .        0,31         .        0,31         .        0,01
LOUISVILLE           -0,07       0,15         .        0,34         .        0,09
CINCINNATI            0,12       1,22         .        1,34      -0,80       0,40
DETROIT                 .       -0,04         .       -0,04      -0,02      -0,05
INDIANAPOLIS         -0,50       1,59         .        1,09       0,04       1,15
CHICAGO              -5,97       7,82      -8,28      -6,39      -7,11     -13,50
ST. LOUIS            -1,44       3,15      -2,66      -0,93      -0,24      -1,17
DES MOINES              .       -0,20         .       -0,20      -0,32      -0,60
MILWAUKEE             0,00       0,25         .        0,20      -0,01       0,25
DULUTH               -0,06      -0,40      -1,39      -3,02      -2,01      -3,03
MINNEAPOLIS           1,53       1,50         .        3,10       8,25      11,30
OMAHA                -0,14       1,51      -0,59       0,70      -0,00       0,76
KANSAS CITY          -0,10      -1,42      -0,21      -1,50      -0,07      -1,87
AMARILLO              0,02       0,30       0,00       0,40         .        0,40
BILLINGS              0,00       0,00         .        0,00         .        0,00
DENVER                0,01       0,07         .        0,10         .        0,00
SALT LAKE CITY          .        0,00         .        0,00         .        0,00
PORTLAND             -0,00       0,02         .        0,12         .        0,02
SAN FRANCISCO         0,06       0,05         .        0,15         .        0,05
LOS ANGELES             .          .          .          .          .          .
**TOTAL*             -6,10      19,70     -13,00       0,42       4,64      10,21
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---COMPARE CORNO1 WITH CORN R1---
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Change in percent

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INTER CASE RESULT COMPARISON TABLES

INCOME COMPONENTS--CORN

  PERCENT DIFFERENCES

                      LAND      ECONOMIC   ECONOMIC      RESIDUAL   PRODCTN    TOTAL
                      RENT      PROFITS    LOSSES        RETURNS    EXPENSES   SALES

BOSTON                  .          .             .          .          .          .
NEW YORK              0,06       3,35         -0,60       0,13         .        0,10
BALTIMORE             0,34       0,17            .        0,23       0,02       0,11
ATLANTA               6,25       4,57        -23,94       4,12       4,25       4,42
JACKSONVILLE            .        0,70            .        0,10         .        0,10
MEMPHIS              -0,93       0,50            .        0,13      -0,00       0,11
HOUSTON               0,47       0,10            .        0,10         .        0,10
NEW ORLEANS             .        0,10            .        0,10         .        0,10
LOUISVILLE           -0,32       1,08            .        0,13         .        0,11
CINCINNATI            0,25       1,40            .        1,14      -0,55       0,17
DETROIT                 .       -0,16            .       -0,10      -0,06      -0,10
INDIANAPOLIS         -0,20       1,04            .        0,12       0,01       0,10
CHICAGO              -1,56       3,07   65055539,90      -1,10      -0,90      -0,45
ST. LOUIS            -2,11       5,70        781,70      -0,16      -0,10      -0,33
DES MOINES              .       -0,06            .       -0,10      -0,04      -0,05
MILWAUKEE             0,10       0,17            .        0,17      -0,01       0,06
DULUTH              -24,10      -6,40        603,40     -17,10      -0,05     -10,67
MINNEAPOLIS           4,04       0,94            .        1,71       3,20       2,62
OMAHA                -0,04       1,44          0,26       0,14      -0,00       0,12
KANSAS CITY          -0,37      -2,23          4,12      -1,75      -0,05      -0,76
AMARILLO              0,06       0,20         -1,69       0,19         .        0,11
BILLINGS              0,04       0,09            .        0,09         .        0,09
DENVER                0,27       0,17            .        0,16         .        0,10
SALT LAKE CITY          .        0,04            .        0,09         .        0,09
PORTLAND             -0,25       0,16            .        0,12         .        0,06
SAN FRANCISCO         0,01       0,10            .        0,14         .        0,06
LOS ANGELES             .          .             .          .          .          .
**TOTAL*             -0,47       0,91          5,55       0,02       0,23       0,14
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The pattern of insecticide use for corn production following organochlorine restrictions is reported by individual regions and for the aggregate corn belt area in Table 12. In general, the solutions indicate a continuation of corn production with alternative soil insecticides on most acreage which had previously been treated with organochlorines. One result of this continuation is a slight reduction in average yields within the infested regions. Yield reductions following restriction are reported in Table 13 and average 0.172 bushels per acre for corn over the entire country.

Solution Impacts, Worse Case Assumptions

On a national basis, the model solution shows an aggregate increase in planted corn acreage of 200,000 acres. This results from the fact that corn, even at reduced yields, is still a more desirable feedstuff than alternative feedgrains in many areas and that farmers would increase their plantings slightly to offset yield reductions. Total changes in land use are reported in Table 14. Slack, or idle, cropland (reported in the last column of Table 14) is reduced by 1,160,000 acres. This means that in total, 1.16 million acres more cropland would be in production following a C/H restriction in 1977 than would be used if C/H remains available. Again, the logic associated with this outcome is found in the farmers' willingness to plant slightly more acres of feedgrains in general to replace corn in particular. This change amounts to approximately a 3.7 percent reduction in slack or idle land between the two solutions.

Table 12. Base model distribution of corn acreage infested by wireworms, rootworms and cutworms by treatment options after restriction of organochlorines, typical case assumptions.

CHICAGO
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	587,49	.	.	587,49
ROOT	WORM	.	1642,27	.	.	1642,27
CUT	WORM	.	779,79	.	.	779,79
UNSPEC	INFESTN	.	820,95	5784,66	.	6605,61
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	3830,50	5784,66	.	9615,16

CINCINNATI
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	48,89	24,37	.	73,26
ROOT	WORM	.	178,58	.	.	178,58
CUT	WORM	.	.	58,05	.	58,05
UNSPEC	INFESTN	.	51,62	1979,03	.	2030,65
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	279,09	2061,44	.	2340,54

DES MOINES
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	260,31	.	.	260,31
ROOT	WORM	.	2978,79	.	.	2978,79
CUT	WORM	.	462,50	.	.	462,50
UNSPEC	INFESTN	.	187,14	4071,66	.	4258,82
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	3888,74	4071,66	.	7960,42

Table 12 (Continued).

DETROIT
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	13.72	.	.	13.72
ROOT	WORM	.	31.46	25.75	.	57.22
CUT	WORM	.	17.96	.	.	17.96
UNSPEC	INFESTN	.	33.14	310.76	.	343.91
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	96.29	336.52	.	432.81

DULUTH
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	3.99	0.39	.	4.39
ROOT	WORM	.	66.61	.	.	66.61
CUT	WORM	.	6.14	.	.	6.14
UNSPEC	INFESTN	.	46.25	134.58	.	180.83
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	122.99	134.97	.	257.96

INDIANIAPOLIS
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	149.71	.	.	149.71
ROOT	WORM	.	450.63	.	.	450.63
CUT	WORM	.	245.29	.	.	245.29
UNSPEC	INFESTN	.	634.05	3577.94	.	4211.99
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	1479.68	3577.94	.	5057.62

Table 12 (Continued).

KANSAS CITY
--- 000 ACRES ---

	C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE WORM	.	7,63	34,10	.	41,72
ROOT WORM	.	477,11	.	.	477,11
CUT WORM	.	67,80	.	.	67,80
UNSPEC INFESTN	.	8,82	1086,88	.	1095,70
OTHER LAND	.	.	.	.	.
TOTAL CORN	.	561,35	1120,97	.	1682,32

MINNEAPOLIS
--- 000 ACRES ---

	C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE WORM	.	74,05	0,75	.	74,80
ROOT WORM	.	1175,76	.	.	1175,76
CUT WORM	.	103,26	.	.	103,26
UNSPEC INFESTN	.	554,23	2681,18	.	3235,42
OTHER LAND	.	.	.	.	.
TOTAL CORN	.	1907,31	2681,94	.	4589,25

OMAHA
--- 000 ACRES ---

	C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE WORM	.	.	.	.	.
ROOT WORM	.	2173,08	.	.	2173,08
CUT WORM	.	61,46	.	.	61,46
UNSPEC INFESTN	.	994,78	1687,16	.	2681,94
OTHER LAND	.	.	.	.	.
TOTAL CORN	.	3229,32	1687,16	.	4916,48

Table 12 (Continued).

ST. LOUIS
--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	190.16	.	.	190.16
ROOT	WORM	.	392.12	.	.	392.12
CUT	WORM	.	270.78	.	.	270.78
UNSPEC	INFESTN	.	457.15	1498.67	.	1955.82
OTHER	LAND	.	.	.	.	.
TOTAL	CORN	.	1310.21	1498.67	.	2808.88

----------1,>. TOTAL CORN TREATMENTS-----------

--- 000 ACRES ---

		C/H A/D	OTHER INSICIDE	NO INSICIDE	OTHER TREATMT	TOTAL CORN
WIRE	WORM	.	1335.94	59.61	.	1395.55
ROOT	WORM	.	10030.13	25.75	.	10055.88
CUT	WORM	.	2029.97	58.05	.	2088.01
UNSPEC	INFESTN	.	4326.60	24000.39	.	28326.99
OTHER	LAND	.	.	.	11778.66	11778.66
TOTAL	CORN	.	17722.64	24143.80	11778.66	53645.10

Table 13.

ENVIRONMENTAL PROTECTION AGENCY - CORN MODEL

INTERCASE RESULT COMPARISON FOR

CROP YIELD: CORN

```
                          UNSPECFD     GROUP1      GROUP2      GROUP3       TOTAL
BOSTON            A          .           .           .           .            .
NEW YORK          B          .           .           .           .            .
BALTIMORE         C          .           .        -0.008         .         -0.004
ATLANTA           D          .        -0.138         .           .          0.212
JACKSONVILLE      E          .           .           .           .            .
MEMPHIS           F          .        -0.024         .        -0.067       -0.000
HOUSTON           G          .           .           .           .            .
NEW ORLEANS       H          .           .           .           .            .
LOUISVILLE        I          .           .           .           .            .
CINCINNATI        J          .         0.112      -0.005       0.038        0.049
DETROIT           K          .        -0.449       0.615      -0.192       -0.154
INDIANIAPOLIS     L          .         0.137      -0.217       0.050        0.044
CHICAGO           M          .        -0.204      -0.194       0.055       -0.221
ST. LOUIS         N          .        -0.467      -0.446      -0.461       -0.456
DES MOINES        O          .        -0.157      -0.032      -1.255       -0.218
MILWAUKEE         P          .        -0.026      -0.025      -0.015       -0.024
DULUTH            Q          .         0.135       3.926      -0.258        1.680
MINNEAPOLIS       R          .         1.160      -0.462      -0.234        0.335
OMAHA             S          .        -0.057      -0.053       0.471       -0.008
KANSAS CITY       T          .         0.748      -0.136      -0.022        0.077
AMARILLO          U          .         0.000       0.000         .          0.000
BILLINGS          V          .           .           .           .            .
DENVER            W          .           .         0.052      -0.144          .
SALT LAKE CITY    X          .           .           .           .            .
PORTLAND          Y          .           .           .           .            .
SAN FRANCISCO     Z          .           .           .           .            .
LOS ANGELES       0          .           .           .           .            .

    *** TOTAL ***            .        -0.172      -0.187       0.422       -0.172
```

Table 14. Net impacts on land use resulting from C/H restriction on corn, by aggregate U.S. subregions, 1977

Region	Barley	Corn	Cotton	Soybeans	Oats	Sorghum	Wheat	Slack
	millions of acres							
North East	0.00	0.01		0.00	0.00	·	0.00	·
South East	0.00	0.39	0.01	-0.26	·	·	0.01	-0.14
North Central	0.16	-1.49	·	1.04	-0.01	0.09	-0.07	0.29
South Central	·	0.20	0.00	-0.01	·	0.23	0.01	-0.43
MTN. & GT. PL.	0.01	1.07	0.07	-1.16	0.26	0.07	0.50	-0.85
North West	·	0.01			·		·	-0.03
South West	0.00	0.00	·		·		0.00	·
U. S.	0.17	0.20	0.08	-0.40	0.25	0.40	0.45	-1.16

0.00 = less than 5,000 acres
· = zero
No entry = nonactive production alternative
Columns may not total to U.S. total due to slight rounding errors

Source: EPA linear programming analysis

As a welfare concept, the model reports total returns to land (net of variable operating expenses). In general, economic theory would suggest that actions which tend to constrain the agricultural sector (with an overall inelastic demand for agricultural products) will lead to price increases which more than offset the income effects of decreased production. The overall impact is higher total returns and higher aggregate profits. The results of the comparative models are entirely consistent with this theory.

As shown in Table 15, the net returns to land for all endogenous production activities in all regions increases by slightly more than $71 million. The regional distribution of this increase varies by region and production alternative; but, on a national level the directional changes is unambiguously positive. The only negative entries in the U.S. total column of Table 15 are for chlorinated hydrocarbon, corn activities. These entries are negative, signifying the reduced returns to land form these activities after cancellation or alternatively, the returns which these activities generated prior to cancellation. On a percentage basis, the C/H cancellation results in increased returns to corn production in the corn belt ranging from 4.4 percent to 23.4 percent and an overall 2.15 percent increase in returns to land in general (U.S. total).

At the national level, the overall impact of the C/H restriction caused the following relative adjustments in the production of the endogenous crops: barley (+2.4%), corn grain (-0.70%), cotton lint (+0.02%), soybeans (-0.09%),

Table 15. Changes in net returns to land resulting from C/H restriction on corn by production alternative, Aggregate U.S. subregions, 1977.

Production Activity Region	North East	South East	North Central	South Central	Mtn. & Gt. Plns.	North West	South West	U.S. Total
	millions of dollars							
Barley, Dryland	0.14	0.01	1.49	0.08	0.68	0.02	0.01	2.43
Barley, Dryland, Fallow				.	1.55	0.13		1.70
Barley, Irrigated				.	0.83	0.10	-0.00	0.93
Corn, Dryland	2.29	1.05	1.02	0.05				4.40
Corn, Irrigated					6.88	1.68	4.96	13.52
Corn, Dryland, No Pesticides			79.44		19.68			99.12
Corn, Dryland, Other Pesticides			6.37		0.41			6.78
Corn, Dryland, C/H			-133.40		-4.40			-137.80
Corn, Irrig., No Pesticides					2.61			2.61
Corn, Irrig., Other Pesticides					12.30			12.30
Corn, Irrig., C/H					-7.29			-7.29
Cotton, Dryland	-0.00	.	2.91	0.79				3.70
Cotton, Irrig.			-2.90	4.31			0.84	2.25
Soybeans, Dryland	-0.01	1.53	46.99	0.01	-10.42			38.10
Soybeans, Irrig.					.			.
Oats, Dryland	0.07	.	0.01	0.00	5.36	.		5.44
Oats, Dryland, Fallow				.	1.41	0.00	.	1.41
Oats, Irrig.					0.03		.	0.03
Sorghum, Dryland	0.00	.	1.67	1.98	4.24			7.89
Sorghum, Irrig.				3.90	-0.90		0.17	3.17
Wheat, Dryalnd	0.37	0.09	-3.45	0.37	2.40	1.25		1.04
Wheat, Dryland, Fallow				.	7.72	0.59	0.08	8.39
Wheat, Irrig.					0.58	-0.78	1.34	1.14
Total Value	2.87	2.67	0.15	6.38	48.80	2.98	7.40	71.25
Ave. Shadow Price, $/acre	0.51	0.29	0.08	0.17	0.35	0.26	2.42	0.24

Table Notes: 0.00 = changes of less than $5,000
. = no change

Source: EPA linear programming analysis

oats (+3.90%), sorghum (+1.90%), wheat (+0.3%). The absolute and relative changes for these crops are reported in Table 16 for seven aggregate subregions of the U.S. As expected, the largest adjustments occur in the North Central and the Mountain and Great Plains regions where corn is the predominant feedgrain. The largest single adjustment is a reduction in corn production of 194 million bushels in the North Central region (6% of that region's base model production). Clearly, this represents a major change in production patterns and would result in major adjustments in land use. From Table 14 it can be seen that most of the equilibrium adjustments occur by substituting soybean production for corn production (1.04 million acre increase in soybeans for a 1.49 million acre decrease in corn). In addition, 160,000 additional acres of barley and 90,000 additional acres of grain sorghum are produced. After all adjustments in the land base of the North Central region have occurred, 140,000 additional acres of cropland are brought into production. Income adjustments associated with these adjustments are depicted in the "North Central" column of Table 15 and result in an increase in net returns to land of $150,000 in aggregate.

Further adjustments which occur in the North Central region (although not reported completely in this section) show an increase in interregional transportation of corn into the North Central from other regions of the U.S. equalling 171 million bushels. As a result, although gross production of corn in the region is reduced by 194 million bushels, feeding of corn to meet livestock demands within the region is reduced by only 22 million bushels. Sorghum grain is the main substitute feedgrain and is increased by 24 million bushels. Sixteen of this 24 million bushel increase in sorghum feeding is supplied via interregional trade.

Table 16. Absolute and relative change in production of endogeneous crops as a result of C/H restriction, by aggregate U.S. subregions, 1977

Region	Commodity						
	Barley bu.	Corn Grain bu.	Cotton Lint Bales	Soy-beans bu.	Oats bu.	Sorghum grain bu.	Wheat bu.
	---millions of units (%)---						
North East	*	0.56 (0.18)	0	-0.04 (-0.28)	0.04 (1.07)	*	-.21 (-.5)
South East	0.09 (8.12)	23.80 (12.63)	0.01 (6.39)	-6.04 (-5.15)	0	*	+.14 (+1.3)
North Central	7.90 (44.85)	-194.28 (- 6.00)	0	38.60 (3.21)	-1.01 (-2.90)	7.83 (11.45)	-2.59 (-1.9)
South Central	0	15.69 (88.61)	-0.05 (-0.93)	-0.62 (-0.27)	0	15.13 (7.18)	.4 (.6)
MTN & GT. PLNS.	0.65 (0.25)	115.68 (8.78)	0.03 (0.54)	-33.62 (-11.09)	12.64 (4.88)	-2.42 (-0.31)	5.88 (0.6)
North West	*	1.19 (6.14)	0	*	0	0	.07 (0)
South West	-0.08 (-3.07)	0.44 (0.24)	0	*	*	0	-.17 (-12)
U.S. Total	8.56 (2.43)	-36.91 (- 0.70)	*	-1.71 (-0.09)	11.61 (3.90)	20.55 (1.90)	3.54 (0.2)

* = Less than 5,000 units

Source: EPA linear programming analysis

EXHIBIT N

ECONOMIC IMPACT OF CHLORDANE/HEPTACHLOR SUSPENSION ON CITRUS PRODUCTION

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
Environmental Protection Agency

Economic Impact of Chlordane/Heptachlor Suspension on Citrus Production

The purpose of this section is to summarize economic and social implications of the cancellation of C/H and aldrin/dieldrin on citrus. Earlier studies conducted by the Department of Agriculture on the impacts of cancelling chlordane and heptachlor are reviewed along with more recent studies by EPA. These studies indicate that cancellation of C/H and other organochlorine alternatives can have significant impacts on citrus production, although the quantities of C/H used on citrus are quite small.

Chlordane Impact Study by USDA

During 1966, 15,000 pounds of chlordane were used to treat approximately 8,300 acres of first and second year citrus plantings to protect them from termites.(1) By 1971, the acreage so treated was estimated to have declined to 3,000 acres of new plantings to which 4,500 pounds of chlordane were applied. The rapid decline in treated acres resulted from the fact that the citrus industry was expanding rapidly with correspondingly high first and second year plantings during the middle 1960's.

This USDA study assumed that there were no effective non-organochlorine substitutes for control of termites on first and second year citrus plantings. This resulted in an estimated loss in value of production of $93,000 for the year 1971 based on the assumption that 5 percent of the 3,000 acres of first and second year plantings would have to be replaced at a cost of $147 per acre for a total of $22,050. The estimate also included production losses arising from the need to replace trees which require six years to reach fruit bearing age and an allowance for cost savings as a result of not treating with insecticides to control termites on citrus trees.

Using the same logic and assumptions inherent in the USDA study, the impact on citrus growers during 1974 would have been $107,000. Damage from uncontrolled termites would have required replanting of approximately .02 percent of Florida's 864,000 acres of citrus. The regional and national economic impacts associated with this loss would be minimal or nonexistent for producers as well as consumers of citrus.

Heptachlor Impact Study by USDA

Limited amounts of heptachlor were used by citrus producers during 1966. According to the USDA study, less than 500 pounds were used for spot treatments to control soil insects and ants in the Southern Plains citrus producing area. (2) No heptachlor was reported for citrus use during 1971. (3) Because of the limited use of heptachlor on citrus in recent years, no estimates were made by the USDA analysis of the economic impact of its cancellation.

EPA Analysis of C/H Cancellation on Citrus

Analysis of unpublished data underlying the USDA survey of pesticide use during 1971 shows California having the highest chlordane use on citrus. This data indicates that 17,800 pounds of chlordane were applied to 9,700 acres of citrus in the United States. California applied about 15,600 pounds to approximately 8,600 acres while Florida accounted for the remaining 2,300 pounds on an estimated 1,200 acres. Use in Florida was primarily for termite control while the California use was directed primarily at control of the Argentine ant which interferes with natural predators of scale insects. It has been further estimated that 25,400 pounds of chlordane was used on 8,112 acres (3.2 percent of California citrus acreage) during 1973.

A five percent granular chlordane compound applied either aerially or with ground equipment at a rate of 100 pounds per acre was the typical dose against Argentine ants during this period.

Substitute control programs used two to four ground applications of diazinon for one application of chlordane or foliar sprays to directly control scale insects. One or two foliar applications of either parathion, malathion, carnaryl, guthion or supracide would be needed as an effective substitute for the chlordane treatment.

Since only a small proportion of the California citrus acreage (3.2 percent) requires treatment for control of Argentine ants and since the substitute control program has a small effect on citrus production costs, the direct regional and national impacts associated with a restriction in chlordane use for California's citrus industry are expected to be small. The impact of cancelling this use would be felt primarily by the grower. Diazinon may not be a long run substitute as it is not presently supported by EPA registration. Such pesticides as parathion could upset pest management programs and require a reorganization of foliar spray schedules. The impacts associated with cancellation of organochlorine insecticide use (including C/H) for citrus production were evaluated by EPA during 1973 in conjunction with the aldrin/dieldrin cancellation hearings. At that time, aldrin was the most widely used organochlorine insecticide and was applied through soil incorporation primarily to control root feeding beetles: use of aldrin for this purpose was limited to Florida. The expert from Florida during the aldrin/dieldrin hearings was that chlordane/heptachlor would be used as an aldrin replacement in the event that citrus uses of aldrin were eventually cancelled.

As a result of the recent aldrin/dieldrin suspension, it can be assumed that C/H will be important alternative insecticides for the control of root feeding beetles in Florida. It should be noted that registrations of C/H for root feeding beetles are not consistent between the state of Florida and EPA. The Florida Insect Control Guide (May 15, 1971) references aldrin, chlordane and dieldrin as recommended pesticides for control of Fuller's Rose Beetle and Citrus Root Weevil. However, there is no corresponding EPA registration for chlordane for Fuller's Rose Beetle. On the other hand, Stauffer Chemical Company does have an EPA registration for use of heptachlor for control of these insects (EPA registration numbers 476-1801 and 476-1129). The use of heptachlor for this purpose does not appear in the Florida recommendations.

. Since the problem associated with root feeding beetles is potentially severe for certain geographic regions of Florida, the role of chlordane and heptachlor in the control of these insects will be analyzed even though this use does not appear in past insecticide use surveys, and the data realting to C/H efficacy is conclusive.

The efficacy data relating to aldrin, dieldrin, chlordane and heptachlor is inconsistent. During 1958, King ran several experiments with these compounds. In one he found that heptachlor provided 96 percent control over Fuller's Rose Beetle while dieldrin and aldrin provided 92.5 percent and 78.2 percent respectively. In a second trial, aldrin performed the best by providing 78.9 percent control with dieldrin yielding 74.6 percent; heptachlor ranked third at 47.6 percent and chlordane performed poorly (29.5 percent). In these tests no statement of statistical significance was associated with treatment means. King concluded from his work that "severe root injury can be prevented by soil applications of 2.0 to 5.0 pounds of technical aldrin, dieldrin or heptachlor per acre" (4).

More recently, Bullock has tested the performance of chlordane, dieldrin and a varied assortment of other compounds. In 1971, the use of dieldrin at a rate of five pounds active ingredient per acre resulted in emergence of 3 beetles per trap while chlordane treatment of 5 pounds active ingredient per acre resulted in a count 9.4 per trap. In this test the control plot yielded 11.4 adults per trap. These mean reported counts were not significantly different from one another at a 5 percent significant level as evaluated by the new Duncan Multiple Range Test (5).

Very little testing of these compounds has occured in recent years. At the same time, C/H have not been used by growers for soil insect control. Therefore, the lack of reliable performance data from experimental work is compounded by a lack of use data under field conditions with the result that the substitutability of C/H for aldrin and dieldrin is most difficult to assess.

Although aldrin and dieldrin were used primarily to control the Fuller's Rose Beetle, they also provided varying control over an associated complex of soil insects including Citrus Root Weevil (*Pachnaeus litus*), West Indian Sugarcane Rootstock Borer Weevil (Diaprepes abbreviata), *Tanymechus lacaena* and Citrus Leaf Notcher. Only minimal control over Diaprepes abbreviata has been afforded by aldrin, dieldrin, chlordane or heptachlor. This recently introduced pest has been subject to quarantine and eradication efforts in recent years with only limited success. According to Robert Brooks of the USDA Cooperative Extension Service, Lake Alfred, sucessful control for this insect has not yet been discovered.

Damage to the citrus tree is primarily by the larvae as they feed upon the roots, reducing both the root system and the canopy. This diminishes vitality and production, culminating in an uneconomical tree. While the damage is apparent, the causes are often ambiguous. Several pests can inhabit the groves and cause similar damage. Often the beetles' infestation can be substantiated only after the tree is removed from the soil. Persistent soil insecticides such as aldrin and dieldrin and perhaps C/H have proven convenient and efficacious because of their persistence (requiring only one soil application every three to five years) to control both termites and beetles. In addition, the soil application of chlorinated hydrocarbons has made it possible to introduce natural insect predators at considerable savings to growers. Part of these cost savings are the result of reduced spraying (by a factor of 3 to 7 applications) of other pesticides. Without an effective soil insecticide, the only option for beetle control is increased spraying of organophosphates to control adult beetles as they migrate fromt he soil to the foliar of trees. This option would probably not provide the same level of control as was maintained by aldrin. Soil insecticides provide maximum protection to citrus groves by interrupting the life cycle as the larvae migrate to the soil and by providing control over the number of adults who can move from the soil back to the foliage. Foliar sprays can be effective in reducing the adult beetle population at the time of application and shortly thereafter; however, because of the variability of the life cycle of the target insects, quarterly foliar applications would probably be required. In this event, the entire spray schedule would have to be restructured together with modifications in the current biological control programs.

Even if chlordane is available for beetle control, due to its lower performance, citrus psecialists feel a modification of past spray schedules may be required. Rather than initiate an additional foliar spray, citrus entomologists would probably recommend that grove managers redesign their foliar schedule. One such option would be to change the summer scalicide spray of ethion and oil which is currently applied in mid-July to parathion and oil in mid-May or June. This option would still provide the scalicide protection as well as some control of adult beetles in the foliage to offset lower efficacy in the soil.

If left uncontrolled, the damage caused by Fuller's Rose Beetle could be severe with impacts distributed unevenly across the citrus growing regions of Florida. Citrus District Five, made up of Atlantic Coast counties including Brevard, Indian River, St. Lucis, Martin, Palm Beach, Broward, Dade, and portions of Volusia is characterized by groves planted on artifically constructed beds, surrounded by draining ditches, which were once partial sqamp land. High water tables limit the depth of the root systems; 90% of the roots are often concentrated in the top 18 inches of soil. In the central part of Florida, citrus roots can penetrate up to twenty feet and average twelve to sixteen feet.

In the coastal counties, a greater portion of the root system is available for larvae feeding. Thus, the same level of beetle infestation can result in greater damage for these trees than for inland groves. Discing in the inland groves to a depth of six inches around the trees may interrupt the pupation stage of the beetle thereby providing marginal, non-chemical control. In the coastal regions, discing to this depth would severely damage the root system. Without cultivation, grass and weeds compete with the tree for available moisture. For this reason, coastal groves are more susceptible to drought which in turn exerts a stress on the tree and leaves it more susceptible to damage by any factor that reduces the root system. The apparent paradox between high water tables and drought damage is explained by the fact that the root penetration is effectively limited by the average height of the water table. As the level declines during dry periods, the peripheral roots of coastal trees are unable to obtain sufficient moisture.

Without adequate control of root feeding beetles, citrus production in coastal counties could prove unprofitable for many groves. Using treatment history as a base to define infested acres (and assuming that treatment is made every three to five years), 25% of Florida's East Coast county citrus acreage could be subject to root damage if adequate control of soil beetles is unavailable. As a percentage of total Florida citrus, this coastal county acreage would affect approximately 6 percent of current citrus production (1972 base).

Because of an inelastic demand for citrus at the farm level, the market impact of a decrease in production would be an increase in farm level income to citrus growers in the aggregate. However, due to the greater potential for insect damage in the East Coast region, these growers could be subject to income reductions if an adequate control agent is not available.

Due to the uncertainty surrounding the efficacy and registration of C/H as soil insecticides for citrus and lack of information surrounding alternative controls for Fuller's Rose Beetle, it is difficult to predict social and economic consequences from C/H restriction. It can be stated that the suspension of aldrin and dieldrin negated the primary control of Fuller's Rose Beetle. Furthermore, if no alternate control agent is discovered, the consequences could be severe for Florida's East Coast growers. Due to currently low income levels and lack of alternative employment, a significant production decline would cause significant social impacts. The extent to which C/H can impact on this situation is unknown and, therefore, the economic and social implications of the C/H cancellation for citrus are difficult to assess with available information.

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
September 1975

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(2) USDA, Economic Impact of Discontinuing Farm Uses of Heptachlor, AER No. 509, ERS, USDA, Washington, D.C., January 1973.

(3) USDA, Farmers' Use of Pesticide in 1971, Agricultural Economic Report No. 252, ERS, USDA, Washington, D.C., July 1974.

EXHIBIT G

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR POTATO PESTS, 1975

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Submitting Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only											
	Chlordane	Heptachlor	Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	10
Potato Insect Complex				1	1	26	27			1		
Army Worm				2	2	25	27		1		1	
Blister Beatles				11	11	16	27		2	9		
Cabbage Leaper				3	3	24	27		1	2		
Colorado Potato Beetle				25	25	2	27		2	11	12	
Cutworms	1		1	9	11	16	27	1	5	5		
Flea Beetles (adult)				23	23	4	27		2	10	8	3
Flea Beatles (larvae)			2		2	25	27			1	1	
Grasshoppers				3	3	24	27		1	2		
Leafminers				3	3	24	27			3		
Mole Crickets			1		1				1			
Stink Bugs				2		25	27			2		
THRIPS				2		26	27		1	2		
Tomatoe Hornworms				1					1			
Tuber Flea Beetle (adult)				1	1	26	27			1		
Tuber Flea Beetle (larvae)	1				1	26	27	1				
White Grubs	4		4	3	11	16	27	4	2	5		
Wire Worms	1		13	6	20	7	27	1	4	12	3	

States: Alabama, Arizona, Arkansas, Colorado, Florida, Georgia, Idaho, Illinois, Louisiana, Maine, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oregon, Oklahoma, South Dakota, Tennessee, Virginia, Washington, Wisconsin, Wyoming

Source: EPA linear programming analysis.

EXHIBIT P

ECONOMIC IMPACT OF THE REMOVAL OF HEPTACHLOR AS A SEED TREATMENT

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
Environmental Protection Agency

Economic Impact of the Removal of Heptachlor as a Seed Treatment

Introduction

Seed treatment is used to decrease stand loss attributable to seed eating insects. It is intended to protect grain and vegetable seed up to the germation period. It is estimated that between 4% and 8.7% of all grain seed (1970-1974) was treated with heptachlor in five mid-western states. Similarly between 8.6 and 20.2% of all seed was treated with one of five major insecticides including heptachlor. Estimates are not available on the intensity of seed insecticide treatment in other agricultural areas.

Summary

1. Seed treatment provides temporary protection from seed eating insects (seed corn maggot, seedcorn beetle, thief ant, wireworms and false wireworms) during germination.
2. Major protection from heavy infestations is provided by more costly and intensive soil treatments. Seed treatment alone does not provide adequate protection under such conditions.
3. Commercial seed producers generally do not apply insecticides to seed for protection during germination.
4. Approximately 9% to 20% of all grain seeds were treated with one of five major insecticides in 5 midwestern states; only 4% to 9% of all grain seeds were treated with heptachlor.
5. Suspension of heptachlor seed treatment would generally result in the use of lindane, diazinon, or a combination of lindane/diazinon.

State recommendations consistently recommend the above as seed treatment alternatives to heptachlor.

Use Patterns and Practices

Seed treatment, which includes the application of fungicides, insecticides and other chemicals to seeds, is a common practice. This practice is an economical way to decrease stand loss and prevent costly replanting and/or yield loss. Seed treatment, however, does not control undesirable pest populations; its efficacy is manifest by the degree of protection afforded only during the period of germination.

Heptachlor, and to a much lesser extent chlordane, provide temporary protection from various soil insects at the time when the plants are most vulnerable to infestation. Heptachlor seed treatment is frequently recommended for use on the most common seed eating pests including seed corn beetles, wireworms, seed corn maggots, thief ants, and false wireworms in 1975 seed insecticide recommendations for various field crops and commercial vegetable in many states. This particular pesticide treatment is used on a large range of grain and vegetable seeds.

While there are other chemicals registered for use as seed treatment, including lindane, diazinon, and Dursban, heptachlor is the most widely used. In 1973 and 1974, 190 and 269 thousand pounds of heptachlor were used as a seed treatment (Exhibit A). A 1973 USDA estimate placed total heptachlor usage as a seed treatment of corn, sorghum and small grain at 11 thousand pounds in 1971(4). A 1972 USDA study estimated that in 1966, 26 thousand pounds of lindane were used for seed treatment (5). It is currently estimated that approximately 12,000 to 15,000 pounds of active lindane ingredient were used in 1975 for seed treatment.

EPA estimates show that only 4% to 8.7% of all grain seeds in 1970, 1972, and 1974 were treated with heptachlor prior to planting in five midwestern states. However, 9% to 20% of all grain seeds were treated with one of five major pesticide seed treatments including heptachlor (Table 1). The above percentages were extrapolated from data given in various state publications concerning the application of both fungicides and insecticides to seed. The extrapolations assumed that the major proportion of commercial seed producers treat seed with a fungicide. Generally, the only insecticide applied by commercial producers is either methoxychlor or malathion for storage protection against seed eating insects (Launer, et al., 1975). The percentage of planters that applied pesticide seed treatment themselves or had their own seed treated commercially (I a+b) was evaluated according to the type of chemical applied. The total percentage of planters having seed treated with an insecticide (Table 1, Part III) was estimated by multiplying the sum of those that treated seed themselves (a) or had their own seed treated commercially (Ib) with fungicides and/or insecticides by the percent that treated the seed with one of the five major seed treatment insecticides (II a,b,c,d, e). A similar calculation estimated the seed treatment use percentage.

Seed treatment is not the sole nor most important method of control of the seed eating insects. Only a small proportion of seeds (9% to 20%) have been treated with any insecticide prior to planting. Primary control of the seed eating insects is provided by direct soil application (Park, 1975). Seed treatment is desirable only to the point where it protects the

Table 1. The Usage of Pesticide Seed Treatment on Grains Seeds[1]
in Various Selected Midwestern States (1970, 1972 and/or 1974)

	Minnesota		Wisconsin		Indiana		Illinois		Iowa	
I. To protect your seed this year from soil insect pests, soil and seed borne disease, was any method of treatment used?[2]	1974 (%)	1972 (%)	1972 (%)	1970 (%)	1974 (%)	1972 (%)	1974 (%)	1972 (%)	1972 (%)	1970 (%)
a. Treated seed myself	7.8	7.1	7.9	10.1	15.0	10.4	20.1	31.6	14.1	15.4
b. Had my own seed treated commercially	2.0	1.5	1.5	4.6	4.2	2.3	2.0	0.9	2.3	3.0
c. Bought commercially treated seed	33.5	29.9	38.9	39.0	41.9	41.4	32.5	34.1	41.4	42.0
d. Did not treat or buy treated seed	21.5	27.6	22.2	9.2	10.1	16.7	16.7	17.4	19.3	10.2
e. Did not know or did not answer	35.2	33.9	32.1	41.2	33.5	32.6	31.8	29.8	25.9	35.6
a+b+c Total % using seed treatment	43.3	38.5	48.3	53.7	61.1	54.1	54.6	56.6	57.8	60.4
a+b Total either treated himself or by commercial treater	9.8	8.6	9.4	14.7	19.2	12.7	22.1	22.5	16.4	18.4
II. If you treated seed yourself did you use the following chemicals?[2]										
a. Heptachlor	51.5	46.0	74.4	57.1	35.1	38.8	19.2	17.5	52.9	47.0
b. Isotox (BHC/Lindane)	30.4	36.0	16.3	18.4	24.6	16.3	23.2	25.4	35.6	30.0
c. Lindane	9.1	10.0	4.7	6.1	8.8	8.2	2.0	6.3	3.4	8.0
d. Diazinon	NA	NA	-	4.1	-	-	23.2	23.0	-	NA
e. Dieldrin	-	8.0	2.3	10.2	35.1	38.8	19.2	17.5	4.6	3.0
a+b+c+d+e Total % using seed insecticide treatment	97.0	100.0	97.7	95.9	100.0	100.0	86.8	89.7	96.5	88.0
III. Total % of seed treated with insecticide (Estimate)	9.5	8.6	9.2	14.1	19.2	12.7	19.2	20.2	15.8	16.2
IV. Total % of seed treated with Heptachlor (Estimate)	5.0	4.0	7.0	8.4	6.7	4.9	4.2	3.9	8.7	8.7

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[1] Crops include all grains

[2] Data from I and II are taken from the following sources:

Prairie Farmer
1974 Illinois and Indiana Survey Report-Agricultural Chemical and Fertilizer
Wallace Farmer (Iowa)
1972 Survey Report-Agricultural Chemical and Fertilizer
Agriculturalist (Wisconsin)

seed during germination. If infestation by the soil eating insects is a serious problem, more costly intensive soil applications may be more economically desirable; soil applications will provide the necessary protection from seed eating pests during both the germination and seedling stages.

In addition, resistance of seed feeding insects to cyclo-dien insecticides is prevalent in certain geographical areas. Seed corn maggot and slender seed corn beetle, for example, are resistant to aldrin, chlordane and heptachlor over the northern and eastcentral areas of Missouri. Iowa no longer recommends chlorinated hydrocarbons in the state because of resistance in these insects. Illinois notes that, among other insects, seed-corn beetles, seed corn maggots and possibly wireworms are no longer effectively controlled by chlorinated hydrocarbons (lindane is included in this group).

State Recommendations

An EPA/USDA survey conducted in early 1975, showed that 19 of 44 respondent states were to recommend either chlordane or heptachlor for seed treatment on sorghum, soybeans, corn and other grains in 1975. Generally, heptachlor was the recommended chemical. The only listed alternatives to the heptachlor seed treatment for the grains was either lindane or diazinon, or a combination mixture of lindane or diazinon. Heptachlor seed treatment, however, was to be recommended by only one respondent state for vegetable seed use, and by three states for the various bean seeds (3).

Verification of the EPA/USDA survey can be found in Table 2. This table includes summary information regarding the official 1975 state insect recommendations for corn, grain, sorghum, small grains and soybeans in selected states. Not all states were surveyed; particular emphasis, however, was given to the high grain producing states. The states surveyed included those that accounted for

Table 2

			Number of States Recommending		Number of states listing alternatives to recommended heptachlor seed treatment				
Crop	Number of states	Major Pests	Any seed treatment	Heptachlor or Heptachlor and other seed treatment	Lindane	Diazinon	Both Lindane and Diazinon	Other	No Alternative
Field crop	(16) Arkansas, California, Delaware, Illinois Indiana, Kansas, Louisiana, Maryland, Minnesota, Missouri, Nebraska, Ohio, Oklahoma, Pennsylvania, Texas, and Wisconsin. (60% of total US Acreage in 1973[1])	Seed Corn Maggot	15	7	1	0	6	0	0
		Wireworm	9	6	1	0	5	0	1
		Seed Corn Beetle	10	7	1	0	6	0	0
Grain Sorghum	(11) Arkansas, California, Illinois, Kansas, Louisiana, Minnesota, Missouri, Nebraska Oklahoma, Texas, and Pennsylvania, (90% of total US Acreage in 1973[1])	Seed Corn Maggot	4	3	0	0	0	0	1[2]
		Seed Corn Beetle	5	5	2	0	2	0	1[2]
		Wireworm	4	3	1	0	1	0	1[2]
		Thief Ant	4	4	2	0	2	0	0
		False Wireworm	1	1	1	0	0	0	0
Small grains	(14) Arkansas, California, Delaware, Illinois, Indiana, Kansas, Louisiana, Minnesota, Missouri, Ohio, Oklahoma, Pennsylvania, Texas and Wisconsin	Seed Corn Maggot	2	1	1	0	0	0	0
		False Wireworm	3	2	0	2	0	0	0
		Wireworm	5	3	2	0	0	0	1
Soybeans	(13) Arkansas, Delaware, Illinois, Indiana, Kansas, Louisiana, Minnesota, Missouri, Nebraska, Ohio, Oklahoma, Pennsylvania, and Wisconsin (63% of total US Acreage in 1973[1])	Seed Corn Maggot	4	1	1	0	0	0	0
		Wireworm	1	0	0	0	0	0	0
		Seed Corn Beetle	[illegible]	1	1	0	0	0	0

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[1] Agricultural Statistics, 1974, USDA.
[2] Texas recommends either heptachlor or chlordane seed treatment only for sorghum.

Source: EPA linear programming analysis

Table 2 (Continued)

			Number of states Recommending		Number of states listing alternatives to recommended heptachlor seed treatment				
Crop	Number of states	Major Pests	Any seed treatment	Heptachlor or Heptachlor and other seed treatment	Lindane	Diazinon	Both Lindane and Diazinon	Others	No Alternative
Sweet Corn	(7) Florida, Illinois, Michigan, Minnesota, New York, Ohio and Wisconsin, (47% of total US Fresh and Processing Acreage in 1973[1])	Seed Corn Maggot	4	1	0	0	1	0	0
		Wireworm	2	2	0	0	1	0	1
Beans	(8) California, Delaware, Illinois, Ohio, Minnesota, New York, Ohio and Wisconsin, (Included 36% of total US Acreage of green beans for processing, 67% lima beans acreage, and 17% dry beans Acreage in 1973[1])	Seed Corn Maggot	7	0	0	0	0	0	0
		Wireworm	1	0	0	0	0	0	0
Peas	(4) Delaware, Minnesota, New York, Wisconsin, (52% of total US Acreage in 1973[1])	Seed Corn Maggot	4	0	0	0	0	0	0
Sugar beets	(4) California, Colorado, Minnesota and South Dakota, (42% of total US Acreage in 1973[1])	Wireworm	3	1	0	0	1	0	0

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[1] Agricultural Statistics, 1974, USDA.

60% of the total United States' planted corn acreage, 90% of the total planted sorghum acreage, and 60% of the total planted soybean acreage (1). The official state recommendations list only lindane, diazinon or both as possible alternatives to the heptachlor seed treatment.

This survey showed six instances where heptachlor seed treatment is recommended but neither lindane, diazinon or any other insecticide is listed as a viable alternative. The exceptions which include seed treatment recommendations for wireworms on field corn, and small grain, particularly oats, in Wisconsin and sorghum seed in Texas are detailed in "Economic Impact of Removal of heptachlor as a Seed Treatment".

A less intensive search of vegetable recommendations are conducted. A brief summary of three vegetable crops, including corn, beans and peas is included. The cited states accounted for 47% of the total U.S. fresh and processing sweet corn acreage, 17, 36 and 67% of the dry, green and lima bean acreage and 52% of the total U.S. green pea acreage in 1973 (1).

Heptachlor does not appear to be the most frequently recommended seed treatment on vegetables. Only one state lists heptachlor as the sole recommended seed treatment for wireworms on sweet corn.

In addition to the above recommendations for grain and vegetables, sugar beet seed may be treated with an insecticide for wireworm protection. However, heptachlor is not the primary treatment as lindane is generally the seed treatment of choice (Lange, 1975).

Review of Alternatives to Heptachlor

Cancellation of heptachlor and chlordane will result in the substitution of other seed treatments. As previously cited the most likely candidates for substitution are lindane, which has been used for a number of years, and diazinon.

Lindane

Lindane is currently produced in the United States by Hooker Chemical Company. On an annual basis total current production capacity is estimated to be approximately 525,000 to 800,000 pounds (Confidential industry sources). Whereas the total use of heptachlor as a seed treatment was only 190,000 and 269,000 pounds of active ingredient in 1973 and 1974 respectively, the domestic production capacity of lindane is inadequate to meet potential increased demand for its use as a seed treatment replacement.

Current efficacy reports on lindane seed treatment vary; additionally the question of its phytotoxicity due to mutagenicity is not clearly answerable (Thomas; Lange, 1975). Thus, its substitutability for heptachlor as a seed treatment is unclear. Though lindane is the most commonly recommended substitute for heptachlor, lack of data prevents accurate assessment as to whether that chemical will always substitute well under all circumstances. Insect control of any chemical can be influenced by many factors including type of seed, species of insects, moisture content of seed, duration of seed storage, planting practices, biological differences of soil insects, population of the infestation, geographic locations (Lange, 1975).

Diazinon

In 1974, diazinon, another frequently recommended substitute for heptachlor seed treatment, was produced in the United States at an estimated 6 to 7 million pounds active ingredient (2). In that year 4.8 to 5.6 million pounds were used domestically for both agricultural and non-agricultural purposes in the United

States (2). The production of this particular chemical is not expected to increase in the next three to four years as there are no current plans for change of the production capacity. Nevertheless, current domestic production capacity is adequate to meet any demand for its use as a seed treatment replacement for heptachlor.

Lack of efficacy and phytotoxicity data for diazinon prevents an accurate appraisal as to whether that chemical will be a good seed treatment substitute for heptachlor under all conditions. As with lindane many factors may affect its performance as a widely used seed protection.

Economic Impact of Removal of Heptachlor as a Seed Treatment

In response to the 1975 USDA/EPA study cited above, agricultural specialists from 9 states provided estimates of the impact of either using a substitute chemical (i.e., usually lindane, diazinon or a lindane/diazinon mixture) or having the lack of a chemical substitute for the heptachlor seed treatment. Seven of the nine respondents anticipated minimal or no effect from the removal of heptachlor as a seed treatment. A 5% to 20% "effectiveness loss on corn grain, sorghum or small grain" was anticipated in New Mexico, whereas possible phytotoxicity resultant from lindane treatment was suspected in Washington state (3). Losses were not expressed in economic terms.

As stated in the section describing state recommendations, six instances were noted where heptachlor seed treatment is recommended with neither lindane, diazinon nor any other chemical listed as a viable alternative (Table 2). Three to four of the exceptions are found in the recommendations of the state of Wisconsin. Heptachlor is the only seed treatment recommended for wireworms on corn, small grains and sweet corn in 1975.

The economic impact on sweet corn is anticipated to be minimal as the wireworm is not of major importance in the areas of Wisconsin where large scale commercial production exists. Field corn infestation of wireworms is frequently of such density that soil treatment is not only recommended but is often more economically desirable. There is, however, no complete picture on the economic impact regarding removal of heptachlor seed treatment from use on small grains. The performance of diazinon is unsure due to lack of supportive data; additionally lindane may not be suitable due to its phytotoxic nature. Therefore, no realistic estimation can be made of the economic impact of the removal of heptachlor as a seed treatment for oats and the other less-important small grains in Wisconsin (Apple, 1975).

The major controversy and discussion that surrounds the question of heptachlor removal as a seed treatment centers primarily in the Southwest. It is estimated that removal of heptachlor as a seed treatment may result in a financial loss of greater than $22 million dollars in the state of Texas (Thomas, 1975). This estimate includes only the cost of replacing and replanting grains sorghum, small grain and corn seed. Seed replacement estimates vary between 10% and 20% of the planted acreage dependent upon crop (Thomas, 1975). Further detailed economic assessments of additional loss due to reduction in yield quality or quantity have not been made.

Wireworms are the major seed eating insect problem in Texas. Diazinon seed treatment is considered to be generally ineffective on wireworms (Thomas, 1975). Though recommended as an alternative to heptachlor/chlordane seed treatment for seed corn beetles, seed corn maggot and wireworms on corn and small grains, lindane is reported to cause various degrees of phytotoxicity particularly on sorghum (Thomas, 1975). Therefore, neither chemical is considered to be an effective seed treatment alternative in the Texas grain producing areas.

Furthermore, cultural techniques are not believed to offer protection against seed eating pests. Planting dates cannot be delayed due to either climatic conditions or to the presence of other pests that can attack at other vulnerable stages (Frisbie, 1975). Potential control from rotation is limited by the fact that many grain growing areas in Texas are not adapted to crops other than grains (Thomas, 1975). Additionally cotton/grain and cotton/sunflower rotations in other locations are not always plausible as the market for cotton may be uncertain and sunflower seeds are a crop of limited demand (Frisbie, 1975). Insect infestations often exhibit densities directly proportional to the seeding rate, therefore, an increase in the rate of seeding will not necessarily produce the desired stand (Frisbie, 1975).

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

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EXHIBIT Q

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR STRAWBERRY PESTS, 1975

Site (Crop)/Pests	No. of States Recommending Control for Pests: Ch. and/or Hept. Only: Chlordane	Heptachlor	Ch/Hept. And other	Other Control(s) only	Total States: Submitting Rec.	Not Submitting	Reporting	Number of States Making Rec. for Control of Pests by Number of Alternative Rec.: 0	1	2-5	6-10	<10
Ants	1		1	1	3	16	19	1	2	--	--	--
Crickets			[illegible]	1	2	17	19	-	2	0	--	--
Cutworms			[illegible]	2	5	14	19	-	4	1	--	--
Mole Crickets	1		1		2	17	19	1	1	--	--	--
Root Weevils (Larvae)	8			2	10	9	19	8	1	1	--	--
Rootworms	1			1	2	17	19	1	1	--	--	--
Spittlebugs				14	14	5	19	-	2	12	--	--
Strawberry Crown Borer	1			5	6	13	19	1	3	2	--	--
Strawberry Root Worm	2			3	5	14	19	2	1	2	--	--
Strawberry Weevil (Adult)				11	11	8	19	-	2	9	--	--
Thrips				4	4	15	19	-	3	1	--	--
White Grubs	10		1	2	13	6	19	10	3	--	--	--
Wireworms	1		1	3	5	14	19	1	3	1	--	--

States submitting recommendations: Arkansas, Connecticut, Florida, Maryland, Michigan, Montana, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Virginia, Washington, and Wisconsin.

Source: EPA linear programming analysis

EXHIBIT R

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR TOMATO PESTS, 1975

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Submitting Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	10
	Chlordane	Heptachlor										
Armyworm				4	4	19	23		2	2		
Cabbage Leaper				10	10	13	23		1	8	1	
Colorado Potato Beetle				9	9	14	23		2	6	1	
Crickets			2	3	5	18	23		2	2	1	
Cutworms			4	12	16	7	23		5	11		
Flea Beetles				13	18	5	23		2	15	1	
Grasshoppers	1	1		3	4	19	23	1	1	2		
Hornworms				15	15	8	23		4	9	2	
Leafminors				6	6	17	23			6		
Mole Cricket			1		1	22	23			1		
Stink Bug				7	7	16	23		1	6		
Tomato Hornworm				2	2	21	23			2		
White Grubs	1				1	22	23	1	1			
Wireworms				4	4	19	23		1	3		
Soil Insects				1	1	22	23		1			

States: Alabama, Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, Ohio Oklahoma, California (aldrin, not chlordane), Pennsylvania, South Dakota, Tennessee, Virginia, Washington, Wisconsin, Oregon.

Source: EPA linear programming analysis

EXHIBIT S

ECONOMIC IMPACT OF SHIFTING TO CHLORDANE/HEPTACHLOR ALTERNATIVES ON LAWN AND TURF

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
Environmental Protection Agency

September, 1975

Economic Impact of Shifting to Chlordane/Heptachlor Alternatives on Turf

Lawns, ornamental turf and golf courses are invaded by numerous insect pests. These pests can be grouped into one or more of three general categories:

1. Turf or grass damaging insects
2. Nuisance pests of man or his pets
3. Health hazards

Turf/Grass Damaging

A list of Federally registered chlordane uses on insects occurring on turf was compared with available state insecticide recommendations for these uses. It was found that chlordane was not recommended for many insects for which it is registered. Chlordane was recommended for insects in the following categories: ants (damage by mound building); white grubs (feeding damage of grass roots by larvae of several species of beetles, including the Japanese beetle); cutworms, sod webworms, and armyworms, mole crickets along the Atlantic seaboard, grasshoppers; and leafhoppers (grass feeding damage). Leafhoppers also transmit plant diseases to other desirable plants, and may be controlled for this reason.

Nuisance

Mites, earwigs, chiggers, ticks, wasps, bees, and fleas are nuisance pests. These insects may not only attack man but may also bite or parasitize pets.

Health

Fleas and ticks may be carriers of Bubonic plague (fleas) and Rocky Mountain Spotted Fever (ticks).

Group 1 insects may cause considerable damage to lawns and turf, primarily by feeding on roots or lower stems of grass causing death of patches of large areas if left uncontrolled. In extreme cases, this may cause major economic damage requiring the replacement of established turf. When attack by any of these insects has been diagnosed, prompt area wide treatment by the several recommended chemicals can usually be expected to achieve control. In addition to the pests named above, there are some locally important pests which are normally controlled with other agents and for which chlordane and heptachlor are not recommended in the sampled states. These include chinch bugs and billbugs in local areas. Earthworms and nightcrawlers are considered pests on golf greens and newly seeded grass, because of their access holes and soil castings (western states mainly).

Group 2 nuisance pests include some insects which are locally important and are controlled by the same recommended chemicals.

Future benefits of chlordane in control of lawn and other insect pests will be affected by development of pest resistance. Widespread use over the last two decades has resulted in documented resistance in pests (Brown, A. W. A., 1971, "Pest Risistances to Pesticides," in Pesticides in the Environment, Vol. 1, Part II, ed. R. White-Stevens). Pest resistance is a phenomenon also in alternative controls, but its extent is likely to be less since alternatives have been used for short periods of time.

Another factor which limits the usefulness of chlordane on lawn/turf is that when used it reduces the earthworm population resulting in a build-up of thatch, thus leading to a sod-bound condition, possible build-up on secondary pests and need for lawn renovation. (Personal conversations with Dr. Luckman, entomologist, University of Illinois, 1975; Dr. Streu, entomologist, Rutgers University, 1975; Dr. Roscoe Randell, et al., University of Illinois, 1975, including published article).

Cost Impact Analysis

Table 1 presents the costs for controlling major lawn/turf pests on one acre of land. It is evident that while many pests are limited to a few regions, white grubs, sod webworms, armyworms and cutworms are widespread. Most states surveyed recommended one or more alternative controls for their listed pests. Only in the cases of California and the 1971 USDA recommendations for white grub control was chlordane the only recommended chemical. Other states recommended on to three alternatives.

Control Costs for Golf Courses and Other Large Area Uses

Costs were computed using 1975 retail prices secured from representative farm co-op stores for typical purchases by large buyers, such as golf courses or other institutions. Table 2 summarizes these costs and provides the basis for evaluating the impact of cancelling these uses of chlordane.

The basis for the golf course analysis was 50 acres of fairways and three acres of greens. Prices for chemicals were from 1975 price list for farm supply stores compiled by USDA. Average costs of treatments for 11 pests for chlordane control were $12.33 per acre ($653.49 for an entire golf course). The average for the lowest cost alternatives was $10.57 per acre ($93.28 less than chlordane for an entire golf course). The average of the second lowest alternative costs is $20.34 per acre which would amount to $424.53 more than chlordane for an entire golf course. It is recognized that the use of alternatives may involve more frequent applications. However, offsetting this is the fact that many greenskeepers have used chlordane for both insect control and as a herbicide to control crabgrass (often with very heavy applications) for several years. This has caused increasing problems of insect resistance to chlordane and dependence on alternatives.

Home Lawns

Control of insects on home lawns requires considerably higher per acre chemical costs than incurred by institutional buyers. Products available to homeowners are typically in lower concentrations of active ingredients and in small packages. For example, control costs for homeowners for sod webworms, armyworms and cutworms would increase from two to seven times over that paid by quantity buyers of the three major chemicals used (chlordane, diazinon, carbaryl), using retain store prices from a typical midwestern city. These same prices when used to compute costs for insect control on a 1/5 acre lot reveal a savings for least cost alternatives and some increase in costs for other alternatives. Any per year increase in costs for an individual, however, assuming a 1/5 acre lot, is minimal (See Table 3).

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September 1975

Table 1. Control Costs per Acre for the Principal Insect Pests on Turf, Lawns, and Golf Courses 1/

EPA Region	Sample States	Pest	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban (R))	Milky Spore Disease	Toxaphene	Dylox	Akton	Malathion	Ronnel Lindane Ethion Aspon Gardona Kelthane Trithion and others
							(Cost per acre active ingredient, $)					
I	CT,NH	Ants	19.51	21.36	21.16							
		White Grubs	14.85	25.53								
		Japanese Beetles										
		Armyworms, Cutworms, Sod webworms	16.88	24.05	17.05							
II	NY	Ants	(follow label instructions)									
		White Grubs	7.16	29.46								
		Japanese Beetles	7.16	29.46			36.40					
		Armyworms, Cutworms Sod webworms		34.37	17.66	78.40					(1-2 lb, AI/AC)	
III	PA,VA	Ants	21.80		22.02	78.40						
		White Grubs	21.80	26.26								
		Japanese Beetles	21.80	26.26			45.30					
		Armyworms, Cutworms, and webworms		26.54	22.12	78.40						
IV	GA,MS, TN	Ants	24.09	21.43	32.67	78.40						28.03 (Ronnel)
		White Grubs	15.36		32.67							
		Japanese Beetles	15.36		32.67		Not available					
		Armyworms, Cutworms Sod webworms	11.93	20.76	29.40	78.40		4.16				
		Fleas	4.86	21.65	3.30						6.40	8.32(lindane)56.00(Ronnel)
		Mites	4.42	21.43	32.67						4.51	(4.62 lb, AI/AC,Trithion)
		Crickets, Grasshoppers	11.90	27.85	32.67	54.00		1.39				
		Earwigs	9.64	21.43	32.67	66.96						
		Chiggers	1.92	21.43	26.14			1.39				1.88(lindane)
		Ticks	1.48	21.43	32.67	21.95		1.39				19.95(Gardona)
		Wasps, Bees	12.02									
V	OH, IL	Ants	1.63	26.95	21.91	72.00						14.80(Heptachlor)
		White Grubs	11.05						12.72			
		Japanese Beetles	22.10	26.81		144.00						14.80(Heptachlor)
		Armyworms, Cutworms Sod webworms	5.51	24.25	21.90	75.60						14.16(Aspon Ill. only)
		Fleas (Ohio only)		6.86	21.91							7.93(Heptachlor)
		Mites (Ohio only)		26.95								5.48(Kelthane)
		Chiggers	2.29	6.86								7.24(Heptachlor)
		Ticks	2.29	6.86		18.00						7.24(Heptachlor)

1/ Application rates were taken from the State Extension Office recommendations for the states identified pooled for the regions. Prices were calculated by Walter Ferguson, ERS, from data secured from seven representative Farm Cooperatives and reflect distributor (wholesale) prices.

Table 1. (Continued)

EPA Region	Sample States	Pest	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban (R))	Milky Spore Disease	Toxaphene	Dylox	Akton	Malathion	Ronnel Lindane Ethion Aspon Gardona Kelthane Trithion and others
			(Cost per acre active ingredient, $)									
VI	OK,NM	Ants										
		White Grubs	13.04	16.23								
		Japanese Beetles										
		Armyworms, Cutworms, Sod webworms	17.31	19.35	33.32	46.80			12.99			3.9 lb AI/AC (Aspon)
		Fleas	14.36	25.31	33.32						6.34	
		Mites		5.80								
		Crickets Grasshoppers	15.65					1.85				
		Earwigs	14.36	25.31	33.32						6.34	
		Chiggers	15.40	8.37				1.85				2.40(lindane)
		Ticks	18.36	25.31	33.32						6.34	
		Leafhoppers	7.97	9.89	22.22						6.34	4.44(Naled)
VII	KS,IA	Ants		28.36	15.50	72.00						
		White Grubs	14.99	38.68	16.42	135.00						
		Japanese Beetles										
		Armyworms, Cutworms Sod webworms	15.97(IA)	26.68	10.96	10.80			35.80			52.97(Ethion)la
		Mites	15.97								38.00	42.29(Ethion)
		Chiggers	15.97								38.00	42.28(Ethion)
VIII (Utah uses USDA recommendations. Few received from SD & WY.)	UT,ND,WY	Ants										
		White Grubs	18.84	5.81								
		Japanese Beetles										
		Armyworms, Cutworms Sod webworms	14.40	38.00	17.72							
		Fleas	3.98	9.89	22.22							
		Mites	3.98	20.75	22.22							
		Crickets Grasshoppers	9.96	31.63				9.25				
		Earwigs	7.97		33.32							
		Chiggers	3.98	9.89	22.22							
		Ticks	3.98	9.[illegible]	22.22							
		Earthworms	27.73	5.81								
		Leafhoppers	3.98	20.76	22.22							
		Wasps Bees	9.96	50.61	17.77							
IX	CA	White Grubs	19.94									
		Armyworms, Cutworms Sod webworms		1.08		78.40						
		Mites		31.60								
		Leafhoppers		31.60								
X	OR	Armyworms, Cutworms Sod webworms	10.74 (Cutworms)	31.91 (sod webworms)					28.10			
		Earthworms	18.67									

Table 2 - Average Chemical Costs Per Acre for Control of Turf, Lawn and Golf Course Insects 1/

A. Ants

EPA Region2/	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban)	Heptachlor
	(Dollars per acre for chemical cost)				
1	19.51	21.36	21.16	---	---
3	21.80	---	22.02	78.40	---
4	24.09	21.43	32.67	78.40	---
5	24.09	26.95	21.91	72.00	14.80
7	---	28.36	15.50	72.00	---
Average	22.37	25.42	22.65	75.20	14.80

B. White Grubs

EPA Region	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban)	Dylox
	(Dollars per acre for chemical cost)				
1	14.85	25.53	21.16	---	---
2	7.16	29.46	---	---	---
3	21.80	26.26	---	---	---
4	15.36	---	32.67	---	---
5	11.05	---	---	---	12.72
6	13.04	16.23	---	---	---
7	14.99	28.68	16.42	135.00	---
8 USDA3/	18.84	---	---	---	---
9	19.94	---	---	---	
Average	15.23	25.23	23.41	135.00	12.72

1/ Application rates were taken from the State Extension Office recommendations for the states identified, and pooled for the regions. Prices were calculated by Walter Ferguson, ERS, from data secured from seven representative Farm Cooperatives and reflect prices, as paid by farmers and institutional buyers.

2/ Sample states, 1-3 per region, were averaged from Table 1 to report chemical costs for single applications of each chemical. Regions listed are all those for which state recommendations were found.

3/ The Extension Service of Utah uses the recommendation published by the U. S. Department of Agriculture for the entire country although many pests covered are not problems in that state; very few pests were covered in the other Region 8 states, North Dakota and Wyoming.

Table 2 - Continued

C. Japanese Beetles

EPA Region	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban)	Milky Spore Disease
	(Dollars per acre for chemical cost)				
2	7.16	29.46	---	---	36.40
3	21.80	26.26	---	---	45.50
4	15.36	---	32.67	---	---
5	22.10	26.81	---	144.00	---
Average	16.60	27.51	32.67	144.00	40.95

D. Army worms, Sodwebworms, Cutworms

EPA Region	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban)	Dylox	Toxaphene	Aspon	Ethion
	(Dollars per acre for chemical cost)							
1	16.88	24.05	17.05	---	---	---	---	---
2	---	34.37	17.66	78.40	---	---	---	---
3	---	26.54	22.12	78.40	---	---	---	---
4	11.93	20.76	29.40	78.40	---	4.16	---	---
5	5.31	24.25	21.90	75.60	---	---	14.16	52.97
6	17.31	19.35	33.32	46.80	12.99	---	---	---
7	15.97	26.68	16.96	10.80	15.80	---	---	---
8 USDA	14.40	28.00	17.72	---	---	---	---	---
9	---	62.17	---	78.40	---	---	---	---
10	10.24	31.91	---	---	28.10	---	---	---
Average	13.15	29.91	22.01	63.83	18.96	4.16	14.16	52.97

E. Fleas

EPA Region	Chlordane	Diazinon	Carbaryl	Heptachlor	Malathion
	(Dollars per acre for chemical cost)				
5	---	6.86	21.91	7.90	
6	14.36	25.31	33.32	---	6.34
8USDA	3.98	9.89	22.22	---	---
Average	9.17	14.02	25.82	7.90	6.34

Table 2 - Continued

F. Mites

(Dollars per acre for chemical cost)

EPA Region	Chlordane	Diazinon	Carbaryl	Kelthane	Malathion	Ethion
4	4.42	21.43	32.67	---	4.51	---
5	---	26.95	---	5.48	---	---
6	---	5.80	---	---	---	---
7	15.97	---	---	---	18.00	42.28
8 USDA	3.98	20.75	22.22	---	---	---
9	---	31.60	---	---	---	---
Average	8.12	21.30	27.44	5.48	11.25	42.28

G. Crickets (mole & field), Grasshoppers

(Dollars per acre for chemical cost)

EPA Region	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban)	Toxaphene
4	11.80	27.85	32.67	54.00	1.39
6	15.45	---	---	---	1.85
8 USDA	9.96	31.63	---	---	9.25
Average	12.40	29.74	32.67	54.00	4.16

H. Earwigs

(Dollars per acre for chemical cost)

EPA Region	Chlordane	Diazinon	Carbaryl	Chlorpyrifos (Dursban)
4	9.64	21.43	32.67	66.96
6	14.36	25.31	33.32	---
8 USDA	7.97	---	33.32	---
Average	10.65	23.37	33.10	66.96

Table 2 - Continued

I. Chiggers

EPA Region	Chlordane	Diazinon	Carbaryl	Malathion	Toxaphene	Lindane	Heptachlor
	(Dollars per acre for chemical cost)						
4	1.92	21.43	26.14	---	1.39	1.88	---
5	2.29	6.86	---	---	---	---	7.24
6	15.40	8.37	---	---	1.85	2.60	---
7	15.97	---	---	18.00	---	---	---
8 USDA	3.98	9.89	22.22	---	---	---	---
Average	7.91	11.64	24.18	18.00	1.62	2.24	7.24

J. Ticks

EPA Region	Chlordane	Diazinon	Carbaryl	Chlor pyrifos (Dursban)	Mala-thion	Toxa-phene	Gardona	Hepta-chlor
	(Dollars per acre for chemical cost)							
4	1.48	21.43	32.67	21.95	---	1.39	19.95	7.24
5	2.29	6.86	---	18.00	---	---	---	---
6	14.36	25.31	33.32	---	6.34	---	---	---
8 USDA	3.98	9.89	22.22	---	----	---	---	---
Average	5.53	15.87	29.40	19.97	6.34	1.39	19.95	7.24

K. Leafhoppers

EPA Region	Chlordane	Diazinon	Carbaryl	Malathion	Naled
6	7.97	9.89	22.22	6.34	4.44
8 USDA	3.98	20.76	22.22	---	---
9	---	31.60	---	---	---
Average	5.97	20.75	22.22	6.34	4.44

Table 2 - Continued

L. Wasp, Bees, Cicada Killers

EPA Region	Chlordane	Diazinon	Carbaryl
(Dollars per acre for chemical cost)			
4	12.02	---	---
8 USDA	9.96	50.61	17.77
Average	10.99	50.61	17.77

M. Earthworms, Nightcrawlers

EPA Region	Chlordane	Diazinon
(Dollars per acre for chemical cost)		
8 USDA	27.73	5.81
10	16.67	---
Average	22.20	5.81

TABLE 3

CHEMICAL TREATMENT COSTS FOR LAWN PESTS AS INCURRED BY HOMEOWNERS USING RECOMMENDED CONTROLS[1]

A. Ants; spot treatment of 1000 square feet, where mounds are present.

Chlordane	Diazinon	Carbaryl	Dursban	Heptachlor
$3.87	$4.88	$1.94	$1.35	NA[2]

B. White Grubs; if found, assume all lawn is treated, 8700 square feet.

Chlordane	Diazinon	Carbaryl	Dursban	Dylox
$33.71	$29.33	$12.63	$21.17	NA

C. Japanese Beetles; treat all 8700 square feet of lawn.

Chlordane	Diazinon	Carbaryl	Dursban	Milky Spore Disease*
$25.00	$50.95	$53.59	$35.33	$11.65

*NOTE: Milky spore disease is also used to control this pest but requires wide area application (e.g., subdivisions or larger) for successful control.

D. Sodwebworms, Cutworms, Army Worms; treat all 8700 square feet.

Chlordane	Diazinon	Carbaryl	Dursban	Dylox	Toxaphene	Aspon
$9.30	$42.46	$8.41	$10.83	NA	NA	NA

E. Fleas; though likely localized where pets are kept, assume entire lawn is treated, 8700 square feet.

Chlordane	Diazinon	Carbaryl	Heptachlor	Malathion
$13.64	$42.46	$16.87	NA	$15.00

F. Mites; same as for fleas, 8700 square feet treated.

Chlordane	Diazinon	Carbaryl	Kelthane	Malation	Ethion
$6.20	$53.68	$16.87	NA	$2.16	NA

G. Crickets (mole and field) and grasshoppers; assume all lawn is treated, 8700 square feet.

Chlordane	Diazinon	Carbaryl	Dursban	Toxaphene
$16.86	$29.54	$16.83	$8.11	NA

---

[1] See attached price list (prices in Cincinnati, Ohio).

[2] NA - retail prices were not available for these recommended chemicals.

Table 3. (Continued)

H. Earwigs; assume all lawn is treated, 8700 square feet.

Chlordane	Diazinon	Carbaryl	Dursban
$13.49	$42.46	$16.83	$19.94

I. Chiggers; require area treatment, assume 8700 square feet.

Chlordane	Diazinon	Carbaryl	Malathion	Toxaphene	Lindane	Heptachlor
$11.53	$13.66	$53.59	$8.45	NA	$1.30	NA

J. Ticks; require area treatment, assume 8700 square feet.

Chlordane	Diazinon	Carbaryl	Dursban	Malathion	Toxaphene	Gardona	Heptachlor
$4.65	$7.60	$16.83	$117.63	$10.57	NA	NA	NA

K. Leafhoppers; because of plant disease transmission, area treatments are needed, assume 8700 square feet.

Chlordane	Diazinon	Carbaryl	Malathion	Naled
$13.49	$9.23	$16.86	$15.00	NA

L. Wasps, Bees, Cicada Killers, etc.; usually spot treatments to nesting areas, assume the equivalent of 1000 square feet.

Chlordane	Diazinon	Carbaryl
$1.94	$9.76	$6.16

M. Earthworm, Nightcrawlers; Not a problem on home lawns, mainly on golf greens and tees.

Attachment A

Region V - Comparable Prices for Chlordane and its Substitutes (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota)

Retail Prices	Package Size	Range	Average
Chlordane 10% WP	1 lb	1.39-1.69	1.55
80% E	1 qt		7.50
45%	1 qt	4.65-5.98	5.30
6% Dust	1 lb		1.20
72%	1 qt	7.49-8.49	
Captar - Malathion	1 lb		1.62
DDVP (vapona)	1 gal		4.05
Lindane 12W	1 lb		2.61
25W	1 lb		4.55
Malathion 57%	1 qt	7.05-8.49	7.77
50%	1 qt		6.98
4% Dust	1 lb	1.37-1.39	1.38
Ronnel 2E	1 qt		4.52
Sevin 50WP	1 lb	2.75-5.00	3.87
5% WP	1 lb	1.39-1.69	1.54
Methoxychlor 25%	1 qt	4.49-5.25	4.87
50 WP	1 lb		4.98
Diazinon 1 lb/gal. conc.	1 qt		6.79
5% Dust	1 lb	2.39-2.49	2.44
Rotenone 1% Dust	1 lb	1.39-1.69	1.54
Dursban 6%	1 qt		6.49

EXHIBIT T

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN PESTS, 1975

TABLES WITH CHLORDANE RECOMMENDATIONS

Table 1	Household
Table 2-7	Home Garden
Table 2	Cabbage
Table 3	Cucumber
Table 4	Lettuce
Table 5	Peas
Table 6	Potatoes
Table 7	Tomatoes

TABLES WITH NO CHLORDANE RECOMMENDATIONS

Table 8-13	Home Garden
Table 8	Cabbage
Table 9	Cucumber
Table 10	Lettuce
Table 11	Peas
Table 12	Potatoes
Table 13	Tomatoes

Reproduced from best available copy.

TABLE 1

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN PESTS, 1975 -- Household (inside)
(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
Household (inside)												
Ants	4		17	5	26	6	32	4	5	14	3	--
Bees	2		5	8	15	17	32	2	4	9	--	--
Booklouse	-		4	7	11	21	32	-	4	7	--	--
Boxelder Bug	1		4	9	14	18	32	1	6	7	--	--
Cadelle	-		1	1	2	30	32	-	-	2	--	--
Carpenter Ants	2		9	-	11	21	32	2	2	7	--	--
Carpet Beetle	1		14	12	27	5	32	1	4	21	1	--
Centipedes	1		6	7	14	18	32	1	6	7	--	--
Chiggers	-		1	--	1	31	32	-	1	--	--	--
Clothes Moths	1		10	9	20	12	32	1	4	14	1	--
Cockroaches	-		17	6	23	9	32	-	--	17	6	--
Crickets	1		9	6	16	16	32	1	2	10	3	--
Earwigs	1		1	14	16	16	32	1	5	8	2	--
Firebrats	-		3	6	9	23	32	-	1	7	1	--
Fleas	-		3	21	24	8	32	-	1	19	4	--
Flour Beetle			9	16	25	7	32	-	2	23	--	--
Gnats				7	7	25	32		1	6	--	--
Hornets			4	7	11	21	32		2	9		
Millipedes	1		7	8	16	16	32	1	5	10	--	--
Mosquitos			1	16	17	15	32	-	2	13	2	--
Powderpost Beetle	1		10	4	15	17	32	1	4	10	--	--
Scorpions	5		1	1	7	25	32	5	1	0	1	--
Silverfish	1		13	9	23	9	32	1	-	19	3	--
Sowbugs	1		5	4	10	22	32	1	1	8	--	--
Spiders	1		15	11	27	5	32	1	2	19	5	--

TABLE 1

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- Household (inside)

(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
Ticks	1		6	10	17	15	32	1	-	13	3	--
Wasps	1		8	7	16	16	32	1	2	11	2	--
Plant - Bagworms			2		2	30	32	-	-	2	-	--
Assassin Bug	1			2	3	29	32	1	2	--	-	--
Bedbugs			2	11	13	19	32	-	2	11	-	--
Elm Leaf Beetle			1	1	2	30	32		1	1	-	--
Springtails	-		4	4	8	24	32		2	6	-	--
Conenose			1	2	3	29	32		-	3	-	--

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Vermont, Virginia, West Virginia.

TABLE 2

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- CABBAGE

(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
CABBAGE												
Mole Crickets	1		1	2	4	26	30	1	3	--	--	
White Grubs	5		9	8	22	8	30	5	16	1	--	
Grasshoppers	1		1	9	11	19	30	1	3	7	--	
Earwigs	0		2	1	3	27	30	0	3	--	--	
Cutworms	1		9	18	28	2	30	1	14	13	--	
Whitefringed Beetle Larvae	1		0	0	1	29	30	1	0	--	--	
Sowbugs	0		1	1	2	28	30	0	1	1	--	
Ant	2		1	0	3	27	30	2	1	--	--	
Root Maggots	0		2	5	7	23	30	0	7	--	--	
Cabbage Maggots	1		3	9	13	17	30	1	11	1	--	
Wireworms	4		10	10	24	6	30	4	20	--	--	
Onion Maggots	0		1	0	1	29	30	0	1	--	--	
Seedcorn Maggots	0		2	4	6	24	30	0	5	1	--	

States Reporting: Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West Virginia, Wisconsin, Wyoming.

TABLE 3

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INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- CUCUMBER
(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
CUCUMBER												
Mole Crickets	1		1	2	4	26	30	1	3	--	--	--
White Grubs	5		9	8	22	8	30	5	16	1	--	--
Earwigs	0		2	1	3	27	30	0	3	--	--	--
Cutworms	1		9	18	28	2	30	1	14	13	--	--
Whitefringed Beetle Larvae	1		0	0	1	29	30	1	0	--	--	--
Sowbugs	0		1	1	2	28	30	0	1	1	--	--
Ants	2		1	0	3	27	30	2	1	--	--	--
Root Maggots	0		2	5	7	23	30	0	7	--	--	--
Cabbage Maggots	1		3	9	13	17	30	1	11	1	--	--
Seedcorn Maggots	0		2	4	6	24	30	0	5	1	--	--
Wireworms	4		10	10	24	6	30	4	20	--	--	--
Onion Maggots	0		1	0	1	29	30	0	1	--	--	--

States Reporting: Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West Virginia, Wisconsin, Wyoming.

TABLE 4

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- LETTUCE

(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
LETTUCE												
Mole Crickets	1		1	2	4	26	30	1	3	--	--	
White Grubs	5		9	8	22	8	30	5	16	1	--	
Earwigs	0		2	1	3	27	30	0	3	--	--	
Cutworms	1		9	18	28	2	30	1	14	13	--	
Whitefringed Beetle Larvae	1		0	0	1	29	30	1	0	--	--	
Wireworms	4		10	10	24	6	30	4	20	--	--	
Sowbugs	0		1	1	2	28	30	0	1	1	--	
Arts	2		1	0	3	27	30	2	1	--	--	
Root Maggots	0		2	5	7	23	30	0	7	--	--	
Cabbage Maggots	1		3	9	13	17	30	1	11	1	--	
Seedcorn Maggots	0		2	4	6	24	30	0	5	1	--	

States Reporting: Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West Virginia, Wisconsin, Wyoming.

TABLE 5

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 — PEAS
(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
PEAS												
Mole Crickets	1		1	2	4	26	30	1	3	--	--	
White Grubs	5		9	8	22	8	30	5	16	1	--	
Grasshoppers	1		1	9	11	19	30	1	3	7	--	
Earwigs	0		2	1	3	27	30	0	3	--	--	
Cutworms	1		9	18	28	2	30	1	14	13	--	
Whitefringed Beetle Larvae	1		0	0	1	29	30	1	0	--	--	
Wireworms	4		10	10	24	6	30	4	20	--	--	
Sowbugs	0		1	1	2	28	30	0	1	1	--	
Ants	2		1	0	3	27	30	2	1	--	--	
Root Maggots	0		2	5	7	23	30	0	7	--	--	
Cabbage Maggots	1		3	9	13	17	30	1	11	1	--	
Seedcorn Maggots	0		2	4	6	24	30	0	5	1	--	

States Reporting: Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West Virginia, Wisconsin, Wyoming.

TABLE 6

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- POTATOES

(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States-Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
POTATOES												
Mole Crickets	1		1	2	4	26	30	1	3	--	--	
White Grubs	5		9	8	22	8	30	5	16	1	--	
Grasshoppers	1		1	9	11	19	30	1	3	7	--	
Earwigs	0		2	1	3	27	30	0	3	--	--	
Cutworms	1		9	18	28	2	30	1	14	13	--	
Whitefringed Beetle Larvae	1		0	0	1	29	30	1	0	--	--	
Wireworms	4		10	10	24	5	30	4	20	--	--	
Sowbugs	0		1	1	2	28	30	0	1	1	--	
Ants	2		1	0	3	27	30	2	1	--	--	
Root Maggots	0		2	5	7	23	30	0	7	--	--	
Cabbage Maggots	1		3	9	13	17	30	1	11	1	--	
Seedcorn Maggots	0		2	4	6	24	30	0	5	1	--	
Onion Maggots	0		1	0	1	29	30	0	1	--	--	

States Reporting: Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West Virginia, Wisconsin, Wyoming.

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INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN PESTS, 1975 — TOMATOES

(PESTS FOR WHICH CHLORDANE RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting Rec.	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
TOMATOES												
Mole Crickets	1		1	2	4	26	30	1	3	--	--	
White Grubs	5		9	8	22	8	30	5	16	1	--	
Grasshoppers	1		1	9	11	19	30	1	3	7	--	
Earwigs	0		2	1	3	27	30	0	3	--	--	
Cutworms	1		9	18	28	2	30	1	14	13	--	
Whitefringed Beetle Larvae	1		0	0	1	29	30	1	0	--	--	
Wireworms	4		10	10	24	6	30	4	20	--	--	
Sowbugs	0		1	1	2	28	30	0	1	1	--	
Ants	2		1	0	3	27	30	2	1	--	--	
Root Maggots	0		2	5	7	23	30	0	7	--	--	
Cabbage Maggots	1		3	9	13	17	30	1	11	1	--	
Seedcorn Maggots	0		2	4	6	24	30	0	5	1	--	
Onion Maggots	0		1	0	1	29	30	0	1	--	--	

States Reporting: Arizona, Arkansas, Florida, GEorgia, Idaho, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West virginia, Wisconsin, Wyoming.

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INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- CABBAGE

(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordene	Heptachlor										
Cabbage												
Army Worms				5	5	27	32	0	1	4	--	
Blister Beetles				19	19	13	32	0	4	15	-	
Cabbage Worms				18	18	14	32	0	1	17	-	
Cabbage Looper				18	19	14	32	0	4	13	1	
Diamond Back Moth				3	3	29	32	0	0	3	-	
Import Cabbageworm				6	6	26	32	0	1	5	-	
Chinch Bug Complex				1	1	31	32	0	-	1	-	
Colorado Potato Beetle				[illegible]	25	7	32	0	7	18	-	
Crickets				2	2	30	32	0	1	1	-	
Cucumber Beetles				23	23	9	32	0	3	20	-	
Flea Beetles				28	28	4	32	0	5	22	1	
Flea Beetle Larvae				1	1	31	32	0	1	-	-	
Leafminers				7	7	25	32	0	2	5	-	
Serpentine Leafminer				2	2	30	32	0	-	2	-	
Lygus Bugs				3	3	29	32	0	1	2	-	
Plant Bugs				3	3	29	32	0	3	-	-	
Potato Psyllid				4	4	28	32	0	2	2	-	
Root Weevils				4	4	28	32	0	2	2	-	
Slugs				3	13	19	32	0	5	8	-	
Snails				3	3	29	32	0	-	3	-	
Sod Webworms				3	3	29	32	0	1	2	-	
Squash Bugs				21	21	11	32	0	8	13	-	
Stink Bugs				13	13	19	32	0	3	10	-	
Harlequin Bugs				10	10	22	32	0	3	7	-	
Thrips				7	7	25	32	0	2	5	-	
Tomato Hornworm				30	30	2	32	0	16	14	-	

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas. Vermont, Virgin'a, West Virginia.

TABLE 9

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 --CUCUMBERS

(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
Cucumber												
Armyworms				5	5	27	32	0	1	4	–	
Cabbage Worms				3	3	29	32	0	0	3	–	
Cabbage Looper				18	18	14	32	0	4	13		
Diamondback Moth				3	3	29	32	0	0	3	–	
Import. Cabbage Worm				6	6	26	32	0	1	5	–	
Colorado Potato Beetle				25	25	7	32	0	7	18		
Crickets				1	1	31	32	0	1	1	–	
Cucumber Beetles				23	23	9	32	0	3	20	–	
Striped Cucumber Beetle				6	6	26	32	0	0	5	1	
Spotted Cucumber Beetle				5	5	27	32	0	0	5	–	
Flea Beetles				28	28	4	32	0	5	22	1	
Flea Beetles Larvae				1	1	31	32	0	1		–	
Leafminers				7	7	25	32	0	2	5	–	
Serpentine Leafminers				2	2	30	32	0		2	–	
Lygus Bug				3	3	29	32	0	T	2	–	
Root Weevils				4	4	28	32	0	2	2	–	
Snails				3	3	29	32	[illegible]		3	–	
Sod Webworms				3	3	29	32	0	T	2	–	
Squash Bugs				21	21	11	32	0	8	13	–	
Squash Bugs Borer				12	12	20	32	0	3	9	–	

TABLE 9

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INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 — CUCUMBERS
(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
Stink Bugs				13	13	19	32	0	3	10	–	
Harlequin Bugs				10	10	72	32	0	3	7	–	
Thrips				7	7	25	32	0	2	5	–	
Tomato Hornworm				30	30	2	32	0	16	14	–	

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio. Oklahoma, Pennsylvania, South Dakota, Texas, Vermont, Virginia, West Virginia.

TABLE 10

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INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- LETTUCE

(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only								
	Chlordane	Heptachlor			Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
LETTUCE												
Armyworms				5	5	27	32	0	1	4	—	
Cabbage Worms				4	4	28	32	0	2	2		
Cabbage Looper				18	18	14	32	0	4	13	T	
Diamondback Moth				3	3	29	32	0	0	3	—	
Import, Cabbage Worm				6	6	26	32	0	1	5	—	
Corn Earworm				11	11	21	32	0	6	5	—	
Cucumber Beetles				23	23	9	32	0	3	20	—	
Spotted Cucumber Beetle				5	5	27	32	0	0	5		
Flea Beetle				28	28	4	32	0	5	22	T	
Flea Beetle Larvae				1	1	31	32	0	1	—	—	
Leafminers				7	7	25	32	0	2	5	—	
Serpentine Leafminers				2	2	30	32	0		2	—	
Lygus Bugs				3	3	29	32	0	T	2	—	
Squash Bugs				21	21	11	32	0	8	13	—	
Stink Bugs				13	13	19	32	0	3	10	—	
Harlequin Bugs				10	10	22	32	0	3	7	—	
Thrips				7	7	25	32	0	2	5	—	
Tomato Hornworm				30	30	2	32	0	16	14	—	

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Vermont, Virginia, West Virginia.

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INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES, 1975 -- PEAS
(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
PEAS												
Cabbage Looper				18	18	14	32	0	4	13	1	
Import. Cabbage Worm				6	6	26	32	0	1	5	-	
Crickets				1	1	31	32	0	1	1	-	
Cucumber Beetles				23	23	9	32	0	3	20	-	
Flea Beetles				28	28	4	32	0	5	22	T	
Flea Beetle Larvae				1	1	31	32	0	1		-	
Leafminers				7	7	[illegible]	32	0	2	5	-	
Serpentine Leafminers				2	2	30	32	0	-	2	-	
Pea Weevils				4	4	28	32	0		4	-	
Sod Webworm				3	3	29	32	0	T	2	-	
Squash Bugs				21	21	11	32	0	8	13	-	

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Vermont, Virginia, West Virginia.

TABLE 12

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 — POTATOES
(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
POTATOES												
Armyworms				5	5	27	32	0	1	4		
Blister Beetles				19	19	13	32	0	4	15	–	
Cabbage Looper				18	18	14	32	0	4	13	T	
Diamondback Moth				3	3	29	32	0	0	3	–	
Import. Cabbage Worm				6	6	26	32	0	1	5	–	
Chinchbug Complex				1	1	31	32	0		1	–	
Colorado Beetle				25	25	7	32	0	7	18	–	
Crickets				1	1	31	32	0	1	1	–	
Cucumber Beetles				23	23	9	32	0	3	20		
Striped Cucumber Beetle				6	6	26	32	0	0	5	1	
Flea Beetles				28	28	4	32	0	5	22	1	
Flea Beetle Larvae				1	1	31	32	0	1		–	
Leafrollers				2	2	30	32	0	1		–	
Leafminers				7	7	25	32	0	2	5	–	
Serpentine Leafminer				2	2	30	32	0	–	2	–	
Lygus Bugs				3	3	29	32	0	1	2		
Plant Bugs				3	3	29	32	0	3		–	
Potato Psyllid				4	4	28	32	0	2	2	–	
Root Weevils				4	4	28	32	0	2	2	–	
Slugs				13	13	19	32	0	5	8	–	

TABLE 12

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1973 — POTATOES
(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
Snails				3	3	29	32	0		3		
Sod Webworm				3	3	29	32	0	T	2	—	
Squash Bugs				21	21	11	32	0	8	13		
Stink Bugs				13	13	19	32	0	3	10	—	
Harlequin Bugs				10	10	22	32	0	3	7	— —	
Thrips				7	7	25	32	0	2	5	—	
Tomato Hornworm				30	30	2	32	0	16	14	—	

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Vermont, Virginia, West Virginia.

TABLE 13

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- TOMATOES

(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only	Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
	Chlordane	Heptachlor										
Tomatoes												
Armyworms				5	5	27	32	0	1	4		
Fall Armyworms				1	1	31	32	0	1	—	—	
Blister Beetles				19	19	13	32	0	4	15	—	
Cabbage Worms				1	1	31	32	0	0	1	—	
Cabbage Looper				18	18	14	32	0	4	13	T	
Imported Cabbage Worm				6	6	26	32	0	1	5	—	
Chinchbug Complex				1	1	31	32	0	—	1	—	
Colorado Potato Beetle				25	25	7	32	0	7	18	—	
Field Crickets				1	1	31	32	0	1	—	—	
Cucumber Beetles				23	23	9	32	0	3	20	—	
Striped Cucumber Beetle				6	6	26	32	0	0	5	1	
Darkling Beetles				1	1	31	32	0	1	—		
Flea Beetles				28	28	4	32	0	5	22	T	
Flea Beetle Larvae				1	1	31	32	0	1		—	
Potatoe Flea Beetle				2	2	30	32	0	1	T	—	
Leafrollers				2	2	30	32	0	1	1	—	
Leafminers				7	7	25	32	0	2	5	—	
Serpentine Leafminers				2	2	30	32	0		2	—	
Lygus Bugs				3	3	29	32	0	T	2	—	
Plant Bugs				3	3	29	32	0	3	—	—	

TABLE 13

INSECTICIDE RECOMMENDATIONS OF SURVEYED STATES FOR HOME AND GARDEN, 1975 -- TOMATOES

(PESTS FOR WHICH CHLORDANE NOT RECOMMENDED)

Site (Crop)/Pests	No. of States Recommending Control for Pests				Total States			Number of States Making Rec. for Control of Pests by Number of Alternative Rec.				
	Ch. and/or Hept. Only		Ch/Hept. And other	Other Control(s) only								
	Chlordane	Heptachlor			Submitting Rec.	Not Submitting	Reporting	0	1	2-5	6-10	>10
Potato Psyllid				4	4	28	32	0	2	2	–	
Root Weevils				4	4	28	32	0	2	2	–	
Slugs				13	13	19	32	0	5	8	–	
Snails				3	3	29	32	0		3	–	
Sod Webworm				3	3	29	32	0	T	2	–	
Squash Bugs				21	21	11	32	0	8	13	–	
Stink Bugs				13	13	19	32	0	3	10	–	
Harlequin Bugs				10	10	22	32	0	3	7	–	
Thrips				7	7	25	32	0	2	5	–	
Tomato Hornworm				0	30	2	32	0	16	14	–	

States Reporting: Alabama, Arkansas, California, Florida, Georgia, Illinois, Louisiana, Michigan, Minnesota, New Hampshire, Washington, Oregon, Connecticut, Idaho, Indiana, Iowa, Wisconsin, New Jersey, New Mexico, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Vermont, Virginia, West Virginia.

EXHIBIT U

ECONOMIC IMPACT OF CANCELLING CHLORDANE AND HEPTACHLOR REGISTRATIONS ON ORNAMENTAL PLANTS IN COMMERCIAL NURSERIES

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs
Environmental Protection Agency

September 1975

Economic Impact of Cancelling Chlordane and Heptachlor Registrations on Ornamental Plants in Commercial Nurseries

Summary of Results

1. Estimated increase in cost to industries to purchase substitute insecticide, $386,940 per year.
2. Average increase in cost to purchase substitute insecticides by individual nursery firms, approximately $77.39 per year.
3. Cost to consumer -- negligible.
4. Estimated use of chlordane in pounds of active ingredient on ornamentals by nurseries in 1974 -- 249,872 pounds.
5. Chlordane is an efficacious and inexpensive insecticide in ornamental use. Heptachlor is rarely, if ever, used in insect control on ornamentals.
6. The major impacts of cancelling chlordane are in two areas:
   (a) Quarantine Program
   (b) Unique insects where chlordane is the only effective control
7. Problems associated with the USDA Quarantine Program. A large volume of nursery plants in interstate commerce are covered by the USDA Quarantine Program (percent unknown). The unavailability of chlordane would either prevent the shipment of these plants or increase the cost of quarantine requirements 10 to 15 times, according to an estimate from the nursery industry.
8. Problems associated with unique insects. In some areas of the country, insects causing damage to ornamental plants are controlled effectively with chlordane only; an example of this is the black vine weevil (taxus weevil).

Introduction

Velsicol Chemical Corporation provided data on pounds of C/H applied for 1973 and 1974 by category of use. Two of these categories are: (1) ornamental and (2) home, garden and lawn. For purposes of this report it is assumed that household use of C/H for ornamental treatment is included in the latter category and the former category, ornamental, includes treatment in the commercial nursery industries.1/ This analysis is restricted to commercial nursery uses of C/H only.

Ornamental plants include shade, flower and fruit trees, conifers, broadleaf evergreens and numerous flowers and shrubs.

The Nursery Industry

The nursery industry includes wholesale growing operations, landscape firms and retail garden centers. A recent study provides an overview of this industry (1). Retail sales of the nursery industry for 1971 were $2.1 billion and wholesale value of these sales was $700 million. In that year expenditures for chemical pesticides used by the industry including insecticides, herbicides and fungicides was $14.8 million. Additional pesticides were purchased, but these were for resale at garden centers. Most pesticide use is at the grower or wholesale level. Pesticide expenditure as a percent of sales to growers was 2.1% in 1971.

1/ The author attempted to confirm this assumption with officials of Velsicol. At the time of this writing no reply has been received from Velsicol.

Insects Controlled

Ornamentals are attacked by numerous insects. According to Webb of USDA, the most serious pest in the absence of chlordane is the black vine weevil (2). One ground application of chlordane per year provides effective control for this pest. A recent USDA/EPA survey of states concerning C/H use lists several damaging insects for which chlordane is the preferred control due to ineffectiveness and/or higher costs of substitute pesticides (3). Some of the most important insects include hog worms, leaf beetles, leaf miners, thrips, Japanese beetles (adults), white fringed beetles, mole crickets and cutworms.

1975 State Recommendations for Ornamental Plants

A review was made of 1975 recommendations for ornamental plants from 15 states. Using these states as a guide, it is clear that chlordane is seldom recommended for most insect-site combinations. However, chlordane is the only recommended insecticide in some instances. Table 1 includes the C/H recommendation from 15 states.

Soil Treatment

Based upon the USDA/EPA survey, many states recommend soil treatment on ornamentals ranging from flowers to trees. The black vine weevil (or taxus weevil) and other root weevils are listed as pests in states across the nation. Other common soil pests are bulb flies, white grubs, and cutworms. More localized are the depredations of the white fringed beetle in the southeast, and the Japanese beetle grubs, Oriental beetle grubs and European beetle grubs in the northeast.

Table 1

Summary of chlordane and heptachlor recommendations on ornamental plants for 1975, 15 states

State	Insect	Chlordane	Heptachlor	Other Insecticides (number)
Florida	Ants	1		
Georgia	Ants	1		
Indiana	Black vine weevil	1		
Alabama	Ants	1		
	Armyworms	1		
	Sod Wedworms		1	3
	White grubs	1		
	Pillbugs and Sowbugs	1		1
Arizona	Boxelder Bugs	1		
	Caterpillars or worms	1		4
	Crickets	1		1
	Cutworms	1		3
	Dackling Beetles	1		
	Earwigs	1		
	Snails; slugs	1		2
Delaware	Black vine weevil	1		
	Narcissus bulb flies	1		
	Grubs	1		
Louisiana	Leaf Miner	1		
Maryland	Japanese Beetles	1		1
	Ants	1		4
Ohio	Bagworm	1		8
	Ants	1		
	White grubs	1		1
	Seed Maggots	1		1
	Wireworms	1		
	Termites	1		
Pennsylvania	Weevils	1		
South Dakota	Boxelder Bugs	1		2
North Dakota	Leaf Beetles	1		2
	Webworms	1		3

Table 1. (Continued)

State	Insect	Chlordane	Heptachlor	Other Insecticides (number)
Tennessee	Giant hornet	1		9
	Asiatic Garden Beetle	1		0
	Taxus Weevil	1		1
	Rose Trips	1		1
Washington	Black vine weevil	1		
	Strawberry root weevils	1		
Virginia	White grubs	1		2

SOURCE: 1975 State, recommendations, USDA/EPA survey, 1974 (3).

Chlordane treatment of above ground pests is also advocated in a few states. The following insects are a composite group of those controlled in these states: ants, leafhoppers, rhododendron borers, poplar and willow borers, leaf feeding beetles, blister beetles, grasshoppers, katydids, various caterpillars, the magnolia leaf miners, and termites.

Foliar Treatment

Seven states will make foliar treatment recommendations for above ground pests of ornamental plants. Some of these pests are boxelder bug, rhododendron borer, willow tree borer, adult black vine weevil, magnolia leaf miner, bagworm, thrips, and adult Japanese beetles. The state of Ohio conducts regulatory programs utilizing both chlordane and heptachlor to prevent the spread of some of these pests.

Quarantine Programs1/

The USDA prohibits the movement of nursery stock from federally quarantined to non-quarantined areas unless certified and treated with an approved insecticide. Chlordane is the only insecticide used on all nursery stock in the quarantine program. One application of chlordane of five pounds active ingredient per acre on nursery stock certifies a plant for three years under the current USDA requirements. According to Brush, 12 to 15 applications of alternatives would be required to achieve equivalent results using chlordane.2/ Control costs would increase greater than 12-15 times, due to higher cost of alternatives and additional labor machinery and other inputs.

1/ One estimate of the amount of chlordane used in the quarantine program by USDA is 204,300 pounds in 1972. Source: RvR Consultants. Production, Distribution, Use and Environmental Impact Potential of Selected Pesticides. Contract No. EPA 540/1-74-001, 1974.

2/ Personal communication between Mr. Ray Brush, Secretary, American Association of Nurserymen and G. K. O'Mara, OPP, EPA, September 4, 1975.

Brush states that one trend in the nursery industry is towards increased specialization in the growing of plants. This trend would tend to increase the volume of plants covered under the USDA quarantine program. According to Bush, the use of chlordane not covered by the cancellation, viz., the dipping of roots and tops of non-food plants is inadequate to meet the needs of plants in shipment. Adequate treatment of balls in this manner results in the loss of earth around roots causing a sharp decline in the survival rates of plants. In addition, there would be difficult disposal problems with the chlordane-treated water because of the large volume and size of many of the plants in question.

Chlordane Use and Cost Data

Data on chlordane use on ornamentals is presented in Table 2. Heptachlor is not used in any important manner for ornamentals. Personal communication with USDA confirms that heptachlor is not used to treat ornamental plants (2).

The price of chlordane in 1971 was $1.30 per pound.[1/] The USDA poundage figure for chlordane in 1971 (Table 2) at $1.30 per pound implies an expenditure of $172,900 by nurseries for chlordane, or 1.2% of total pesticide expenditures of $14.8 million.

[1/] 1971 price is an estimate by EPA.

Table 2. Chlordane used by the nursery industries annually in pounds of active ingredient

Year	Chlordane used by nursery industries AI Lb
1971	133,000 1/
1973	227,882 2/
1974	249,872 2/

Source:

1/ Andrilenas, P.A., Quantities of Pesticides used by Farmers in 1971. ERS, USDA. Washington, D.C., 1973

2/ Letter: From Sellers, Conner and Cuneo (counsel for Velsicol Chem. Corp.) to W. Reukauf, Attorney, EPA. Washington, D.C., June 23, 1975.

Economic Impacts

Comparison of Cost of Chlordane and Substitute Pesticides

Prices of chlordane and six other insecticides are listed in Table 3. Prices should be representative for 1975. Table 4 lists five major representative pests which attack ornamentals. In addition to chlordane, five registered insecticides are included. The entries in Table 4 are application rates in pounds of active ingredient per 100 gallons of water. The numbers in parenthesis include the frequency of application per year.

Table 5 provides an indication of costs to the nursery industries if chlordane is cancelled for this use.1/ The entries in Table 5 are derived from information in Tables 3 and 4 and are obtained by averaging the information across the five insects in Table 4. Rates of application and number of applications as specified by state recommendations are used to estimate the pounds of active ingredient of each substitute required per year relative to that of chlordane. Total pounds of chlordane used in 1974 by nurseries (Table 2) provides an upper estimate of use and retail price (Table 3) is used to estimate expenditures for chlordane. Similar analysis is provided for substitute chemicals. Total cost of chlordane and for its substitutes (assuming each other insecticide substitutes entirely for chlordane) are shown in column 9 of Table 4.

One method to estimate increased costs due to a chlordane cancellation is to use an equally weighted average of the total cost of the five substitute

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1/ The reader should be aware of the limitations of these cost estimates. Their accuracy depends upon several assumptions, including comparable efficacy, reliable use estimate of chlordane in nurseries, and others.

Table 3. Price of Pesticide Per Pound of Active Ingredient for 1975[1/]

Insecticide	Retail Price 1975 Per #AI
Chlordane	$1.77
Toxaphene	1.06
Carbaryl	2.27
Malathion	2.68
Diazinon	5.12
Methoxychlor	2.76
Dimethoate	8.57

[1/] Source: Prices were obtained from the Economic Research Service, USDA and represent prices paid by farmers and nurserymen in several regions of the U.S. in quantities of 5 gallon containers.

Table 4.

REGISTERED USE RATES FOR CHLORDANE AND 5 ALTERNATIVES ON 5
PESTS OF SHADE TREES, ORNAMENTALS, PERENNIALS, AND ANNUALS

Insecticide and Rate (Active Ingredient)

Pest	Chlordane	Carbaryl	Diazinon	Dimethoate	Malathion	Methoxychlor
Bagworms	1 lb/ 100 gal. (1)	1 lb/ 100 gal (2)	0.5 lb/ 100 gal. (1)	1.0 lb/ 100 gal (1)	1.25 lb/ 100 gal. (1-2)	N.R.
Leaf Beetles	1 lb/ 100 gal. (1-6)	1 lb/ 100 gal (2-12)	N.R.	N.R.	N.R.	0.5-1.0 lb/ 100 gal. (1-6)
Leaf Miners	1 lb/ 100 gal. (1)	1 lb/ 100 gal. (2)	0.5 lb/ 100 gal. (1)	0.25 lb/ 100 gal. (1)	1.25 lb/ 100 gal. (1)	N.R.
Thrips	1 lb/ 100 gal. (1)	1 lb/ 100 gal. (1)	0.5 lb/ 100 gal. (1)	0.5 lb/ 100 gal. (1)	1.0 lb/ 100 gal. (1)	N.R.
Japanese Beetle Adults	1 lb/ 100 gal. (1-6)	1 lb/ 100 gal. (1-6)	N.R.	N.R.	1.0 lb/ 100 gal. (2-12)	1-1.5 lb/ 100 gal. (1-6)

(#) Anticipated # of Applications/Season

Source: Compiled by Ecological Effects Branch, C & E Division, OPP, EPA, August, 1975.

Table 6. Estimated Costs of Chlordane and Registered Substitute Insecticides

Insecticide	Rate of Application Range	Rate of Application Median	Freq. of Application/Yr. Range	Freq. of Application/Yr. Median	#A.I. Required to Substitute for #1 Chlordane	Total Pounds Chlordane Used Per Year	Total # Required Per Yr. to Substitute for Chlordane	Price/# A. I. Retail Level	Total Cost Per Year To Achieve Equivalent Insect Control Of Chlordane (Col. 7 X Col. 8)
Chlordane	1#/100gal	1#/100gal	1-4	2.	1.00	250,000			
Carbaryl	1#/100gal	1#/100gal	1-12	3.1	1.00	-------	250,000	1.77	442,500
Malathion	1-1.2#/100gal.	1.125#/100gal	1-12	2.68	1.13	-------	460,020	2.27	958,600
Diazinon		.5#/100gal.	1	1	.50	-------	370,000	2.68	991,600
Methoxychlor	.5-1.5#/100gal.	1#/100gal.	1-6	2.5	1.0	-------	62,500	5.12	320,000
Dimethoate	.25-1.0/100gal.	.625#/100gal.	1	1	.63	-------	450,000	2.76	1,242,000
							80,000	6.57	[illegible]

Source: Compiled by Economic Analysis Branch and Ecological Branch, Criteria and Evaluation Division, Office of Pesticide Programs, EPA.

chemicals from Table 5. The average expenditure for the five substitute chemicals is $829,440 per year and this compares with $442,500 spent on chlordane. The cost of the nursery industry to replace chlordane is $386,940 per year.

Summary

To the typical nursery firm and to the nursery industry, impacts measured in terms of absolute changes in costs are small. An increase in cost of $386,940 relative to industry sales is in the range of 0.02% to 0.03%. Assuming there are approximately 5,000 firms in the industry, average cost per firm would increase about $77.39 per year to replace chlordane with other insecticides. Costs to the consumer would be negligible.

To assess the value of chlordane, it is also necessary to determine its value relative to other insecticides in the control of pests. For certain pests, such as the black vine weevil, chlordane is the only effective insecticide in some areas of the country, according to 1975 state recommendations. In cases such as these, chlordane would have a very high benefit/cost ratio. A qualitative assessment of the value of chlordane in ornamental use should be determined in the C/H suspension hearings. It cannot be done quantitatively with available information.

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975

References

(1) Horticultural Research Institute Inc. Research Summary - Scope 11 of the Nursery Industries. Hort. Res. Inst. Bethesda, Md., 1973.

(2) Personal communication between R. Webb, Animal and Plant Health Inspection Service, USDA and G. K. O'Mara, Office of Pesticide Programs, EPA. August 25, 1975.

(3) USDA/EPA. C/H Survey to obtain use estimates and use recommendations for 1975 by states and territories. Survey distributed by Cooperative State Research Service, USDA. Washington, D.C., December 16, 1974.

EXHIBIT V

SURVEY OF PRODUCERS OF MAJOR SUBSTITUTES FOR CHLORDANE/HEPTACHLOR

Gary Ballard
Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975

Survey of Producers of Major Substitutes for Chlordane/Heptachlor

The following information is based on telephone contacts with representatives of the firms producing the major alternatives to chlordane and heptachlor. Contacts were made during late August and early September 1975.

Furadan - Furadan is a proprietary compound of the FMC Corporation. Jim Campbell (Product Manager for Furadan) stated that corn is the primary market for furadan and this market will be fulfilled by FMC to the extent possible. A major expansion of production facilities occurred in late 1973, which increased supplies substantially for 1974 and 1975. The supply situation will be essentially the same for 1976. There is a large export market for furadan and the relative proportions allocated to the domestic and foreign markets can and will be adjusted given the demand situations. Plans are being reviewed for additional expansion of production facilities but the expansion would require two or three years to complete. In the near term any expansion in domestic sales would come at the expense of exports. FMC is willing to follow this course at least to some degree in order to meet the needs of domestic corn production and to protect its market in the Corn Belt.

Dyfonate - Dyfonate is a proprietary product of Stauffer Chemical Company. Herbert Odin (Manager of Sales Services) stated that there would be full availability of supplies to meet the foreseeable demand for dyfonate in 1976. New facilities for production are currently under construction and will be completed for the 1977 marketing year. The new capacity is expected to increase the supply of dyfonate by 50% over the 1974-75 levels. There will be a continuing upward trend in the supply of dyfonate.

Dasanit - Dasanit is a registered trademark of the Chemagro Agricultural Chemicals Division of Mobay Chemical Corporation (Chemagro). Ken Schuttler (Product Manager of Chemagro) explained that the production of Dasanit has been hampered by a shortage of intermediate feedstocks. Steps are currently being taken to alleviate the shortages but the prognosis for success is at present uncertain. There are no plans currently to expand production facilities. Production should, however, increase by an unknown percentage once the intermediate shortages are solved. As for the possibility of increasing supplies, Dasanit is not produced with dedicated equipment, that is, other products are produced with the same facilities. If there are sufficient intermediate materials, the product mix could be adjusted to a higher proportion of Dasanit.

Farm Chemicals Handbook (1975) also lists Bayer AG of West Germany as a basic producer of Dasanit. This presents the possibility of increasing the domestic supply of Dasanit by importing the compound from West Germany. Possible levels of importation are not known, however.

Mocap - Mocap is a registered trademark of Mobil Chemical Company. Staley Felton (product manager for Mocap) stated that Mobil was capable of meeting the expected demand for Mocap. Mocap is primarily used as a nematicide on tobacco in the southeast. Mocap is registered for use against corn rootworms and wireworms. The use of Mocap on corn is now the second largest market in terms of pounds used. A portion of the use on corn is for control of nematodes in the southeast but the breakdown between nematode control and soil insect control is not available. Mobil has test results which show that Mocap is an effective control of cutworms on corn and an application for experimental use of Mocap for use against cutworms on corn is being prepared for submission to EPA to obtain data for registration. Art Huvar (Manager, Registration and Development) stated that a bottleneck has occurred in this application in that the application must contain the site and name of the persons conducting the tests. Since cutworm infestation is variable in many areas it is difficult to contract for test sites in advance and be sure that there will be a pest infestation that will provide reliable data on the efficacy of the compound. Mobil hopes to overcome this problem and obtain an experimental use permit for cutworms on corn for 1976. Three factors are involved in assessing the availability for mocap. First, approximately 20% of Mobil's production is exported. The proportion allocated to the domestic market can be varied. Second, mocap is not produced in dedicated facilities, therefore, the product mix can be varied to favor higher production of mocap. Third, the physical plant can be operated for longer periods of time by adding one or two shifts to the present work force. Thus, given sufficient demand and new materials, mocap supplies can be increased on relatively short notice.

Sevin - Sevin is a registered trademark of Union Carbide Corporation. Bill Nissen (Agricultural Marketing Manager) stated that the supplies of Sevin products were tight in 1974 and in 1975. New production facilities are currently being added which will expand capacity by 15% by 1976 and a total of 50% over the next three years. Union Carbide considers corn to be one of its major markets for Sevin and efforts are being made to expand their sales in that area. Sevin is currently used in bait formulations to control cutworms. Union Carbide hopes to gain farmer acceptance of using an oil formulation of Sevin against the adult rootworm late in the season. The bait formulations are considered by Union Carbide to be a minor use for

Sevin since bait formulations contain relatively small amounts of active ingredient. Union Carbide hopes that a greater gain in sales will occur in the use of spray treatments against the adult pests.

Bux - Bux is a registered trademark of the Chevron Chemical Company. Donald Dye (Coordinator for Regulatory Affairs) stated that the use of Bux is declining due to the development of resistance in corn rootworms. It is felt that Bux usage will continue to decline and the product will no longer be a strong substitute for use against corn rootworms.

Dursban - Dursban is a registered trademark of the Dow Chemical Company. Bob Morgan of Dow stated that the supply of Dursban would be measurably increased over the current year. Also Dow is actively attempting to expand the market for Dursban use on corn. Although the increase in supply is not available, Dow views its supply of Dursban to be sufficient to meet demand barring unforeseen shortages of intermediates.

Diazinon - Diazinon is a registered trademark of Ciba-Geigy Corporation. Carl Kensil of Ciba-Geigy stated that there would be no increase in availability of Diazinon for 1976 over the present level of supply. There are some recurring shortates of intermediates which have held down the production of Diazinon. Steps are being taken to solve these shortages. Also the physical production facilities are being expanded and increased capacity will be available for 1977 if adequate intermediates are available.

Although Diazinon is used to some extent on corn, it is not as effective against rootworms as some other products are. Diazinon is, however, used for wireworm and cutworm control. Although Diazinon is an effective control for cutworms, Ciba-Geigy feels that the highly variable nature of cutworm infestations minimizes the demand for Diazinon. The drawback in using Diazinon on cutworms is that the cost of the product detracts from its acceptance by growers since in many cases a treatment for control of cutworms with any chemical is going to be prophylactic in years when cutworms do not appear at economic levels. It is Ciba-Geigy's view that growers in most areas regard rootworm control as the primary consideration in selecting a pre-emergence corn soil insecticide. Control of wireworms and cutworms then becomes incidental to rootworm control. Thus, unless a product is effective against rootworms, the market for that product will not be significant. With these points in mind, even though Diazinon is felt to be effective against wireworms and cutworms by Ciba-Geigy, the corn market is not felt to be of major area in which sales can be expanded.

Ethion - Ethion is a registered trademark of the FMC Corporation. Jim Campbell (Product Manager at FMC Corporation) stated that Ethion competed with chlordane for uses on sod and ornamentals. The largest market for Ethion is on citrus in Florida; this market is not in competition with either chlordane or heptachlor. The relatively small amounts of Ethion needed for sod and ornamental treatment should be in sufficient supply.

Aspon - Aspon is a registered trademark of Stauffer Chemical Company. Herbert Odin (Manager of Sales Services) stated that Aspon is considered a speciality product used only for cinch bugs and sod webworms in turf. The market is considered minor in terms of pounds of active ingredient. Stauffer feels that there will be no availability problems for Aspon.

Orthene - Orthene is a registered trademark of Chevron Chemical Company. Donald Dye (Coordinator for Regulatory Affairs) stated that 1975 was the first year for which Orthene was available. The current supply is described as limited. A pilot plant produced the 1975 supply of Orthene. There will be a small increase in supply for 1976 but the availability will still be limited. A plant is now under construction which is scheduled to be in production of Orthene for the 1977 season.

Toxaphene - Toxaphene is produced by several firms including Hercules Incorporated. Henry Pierce (Director of Agricultural Chemicals Division) stated that the use of toxaphene on corn is variable. Toxaphene is applied for control of army worms and cutworms on corn. These applications are required only when periodic outbreaks of the pests occur. There were outbreaks of cutworms on corn in 1975 and the use of toxaphene rose significantly in the corn producing states. Hercules had an increase in sales of technical toxaphene to formulators in the Midwest in 1975. Supplies are also typically available from formulators in the cotton producing states. Hercules feels that there is sufficient production capacity to meet the demand for toxaphene when outbreaks of cutworms occur as they did in 1975.

Lindane - Lindane is produced solely in the United States by the Hooker Chemical Company. Lindane is made abroad. However, foreign demand prevents substantial importation of the chemical into the U.S. In 1972, farm use of BHC and lindane, which is more commonly used, was estimated to be 643 thousand pounds (USDA, Economic Impact of Discontinuing Farm Use of Lindane and BHC, 1972). Total domestic production of lindane is thought to be less than 1 million pounds, although no specific estimates are available.

Current total capacity is inadequate to meet total demand for all uses according to a recent conversation with Mr. Goldman, of Hooker Chemical Company. Lindane production will be essentially the same until 1977 or 1978 as there are no current plans for increase production capacity. (Decisions to expand production have been delayed pending the outcome of carcinogenicity tests).

Gary Ballard
Economics Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975.

Contacts

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EXHIBIT W

REVIEW OF THE SUPPLY OF SUBSTITUTES TO CHLORDANE AND HEPTACHLOR UNDER SUBSTITUTE CHEMICAL PROGRAM

Economic Analysis Branch
Criteria and Evaluation Division
Office of Pesticide Programs

September, 1975

Supply characteristics of registered substitutes for chlordane and heptachlor

Type of Insecticide	Estimated Produc-tion	Est. Domestic Full Capacity Production	Estimated Imports	Estimated Exports	Comments
	pounds				
Methyl parathion (1)	51 million (1972)	perhaps as high as 100 million	1.1 million (1972)	12.5 million (1972)	Some of the methyl parathion production capacity can be used to manufacture other organophosphates.
Azodrin (2)	9-11 million (1973)	14 million	none	4.5-6.0 million (1973)	Production capacity may expand 25 to 30 percent if the feedstock shortage problem is solved. Additional supply possibilities from foreign producers conceivable.
Dursban (3)	5-7 million (1973-1974)	NA	not substantial	not substantial	Production is well below full capacity because of the shortage of the feedstock DEPCT. Construction of a DEPCT plant is underway. A dursban production plant is planned for completion in 1976 in Europe to help meet U.S. demand.
Diazinon (4)	6-7 million (1974)	6-7 million (1974)	negligible	1.0-1.5 million (1974)	Production capacity may expand if the feedstock shortage problem is solved. Two foreign producers are known to exist.
Dimethoate (5)	3 million (1973)	NA	not substantial	not substantial	Existing plant capacity can be used to manufacture other organophosphates.
Guthion (6)	4 million	NA	negligible	NA	Production capacity is limited only by the availability of feedstocks. One foreign producer is known to exist.
Aldicarb (7)	1.0-1.5 million (1972)	NA	none	400,000-700,000 (1972)	
Malathion (8)	24 million (1972)	NA	153,000 (1972)	8 million (1972)	
Demeton (9)	none	none	273,000 (1971)	none	
Phorate (Thimet) (10)	8 million (1971)	28 million (1969)	none	NA	Existing plant capacity can be used to manufacture other organophosphates. Feedstock shortages will probably constrain supply in 1975.
Furadan (11)					Tight supply expected in 1975 with easing expected in 1976.
Dyfonate (11)					Adequate supplies available in 1975 and it may be possible to fill some of the shortages in phorate and furadan.
Carbaryl (11)					Tight supplies expected, but capacity should increase by 50 percent at the end of 1976. Supply constraints may exist because of feedstock shortages.
Counter (11)					High volume of production for this new registration cannot be expected until 1976-1977. Perhaps a million pounds can be produced in 1975 and possibly a multi-million pound plant will be available in 1976.

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SOURCES:

(1) EPA, OPP, Initial Scientific and Minieconomic Review of: Methyl Parathion, October 1974.

(2) Arthur D. Little, Inc., Azodrin: Initial Scientific and Mini-Economic Review, draft, Cambridge Massachusetts, October 1974.

(3) Arthur D. Little, Inc., Dursban: Initial Scientific and Mini-Economic Reviews draft Cambridge, Massachusetts, December 1974.

(4) Arthur D. Little, Inc., Initial Scientific and Mini-Economic Review of Diazinon, draft, Cambridge Massachusetts, February 1975.

(5) Arthur D. Little, Inc., Initial Scientific and Mini-Economic Review of Dimethoate, draft, Cambridge, Massachusetts, January 1975.

(6) Arthur D. Little, Inc., Guthion Initial Scientific and Mini-Economic Reviews, draft, Cambridge, Massachusetts, October 1974.

(7) Midwest Research Institute, Initial Scientific and Mini-Economic Review No. 5 Aldicarb, draft, Kansas City, Missouri, August 1974.

(8) Midwest Research Institute, Initial Scientific and Mini-Economic Review of Malathion, draft, Kansas City, Missouri, September 1974.

(9) EPA, OPP, Demeton Mini-Economic Review, draft, July 1974.

(10) EPA, OPP, Minieconomic Review Phorate, draft, June 1974.

(11) Theodore Riedeburg Associates, Pesticide Use for Control of Soil Borne Insects in Corn in the States of Indiana, Illinois, Iowa, and Missouri.

EXHIBIT X

ASSUMPTIONS USED IN COMPUTATION OF ENERGY IMPACTS OF MANUFACTURING ALTERNATIVES TO CHLORDANE AND HEPTACHLOR

Chemistry Branch
Criteria and Evaluation Division
Office of Pesticide Programs

May, 1975

Assumptions Used in Computation of Energy Impacts of Manufacturing Alternatives to Chlordane and Heptachlor

Tables 21 and 21 (Part I, p. 83, 84) summarize the energy impact of cancellation of chlordane and heptachlor based on representative substitutes: carbofuran, diazinon, and carbaryl. Carbofuran, a member of the carbamate class of pesticides, is the major substitute. Diazinon is an important substitute among the organophosphate pesticides. It was chosen also for its chemical complexity. Carbaryl is an inexpensive and widely available carbmate. Below is a list of the important assumptions made in developing Tables 21 and 22. These are followed by remarks on the influence of some general factors.

Assumptions:

1. A private study on chlordane and heptachlor energy requirements was used to derive energy inputs (Syracuse University Research Corporation). Comparing process steps, the energy and electricity requirements from this study were extrapolated to the three substitute pesticides selected -- carbofuran, diazinon, and carbaryl. The dicyclopentadiene feedstock for chlordane and heptachlor was assumed to be obtained at no energy cost. The energy costs for the chlordane feedstock were calculated thermodynamically as 3.44 kWh/lb chlordane and 2.82 kWh/lb heptachlor, respectively. For the three substitute insecticides considered, the feedstock chemicals were traced back to natural raw products or petroleum distillates, with appropriate process energy (electricity and heat) assigned to each step.

2. The use chosen as representative was that of a soil insecticide on corn and potatoes.

3. None of the feedstock chemicals are obtained as by-products of other chemicals. Rather, each has its own independent market and production economics. An exception was made in the case of chlorine. Invariably produced with caustic soda, chlorine was assigned only half its actual energy requirement. The assumption that each feedstock chemical is produced in a distinct, independent process is in error. We were unable to evaluate the direction of the error in estimating the impact of the studied pesticides on petroleum consumption. The American chemical industry is often able to accomodate supply and price fluctuations despite joint production. Felicitous by-product relationships are common, often by design. For example, phenol, raw material for carbofuran, can be made with either chlorine and caustic or propylene. If made with the latter, a by-product is acetone, which in turn is a raw material for diazinon production.

4. Similarly, in calculating "petroleum for feed" in Tables 21 and 22, it was assumed that petroleum processing can be adjusted to produce 1 lb of the feedstocks from 1 lb of crude oil. Since only

about 10% of petroleum distillates go to petrochemicals, and around 7% of petrochemicals (by weight) are pesticides, this assumption may be valid even over a short run.

Despite abundance of divertible petroleum, shortages of particular chemicals may occur, e.g. because of allocation or limited facilities, or because joint processes tie production of some materials to that of others. The effect might be a larger impact on petroleum consumption than estimated here. On the other hand, carbaryl does not demand a petroleum base. Its increased use could balance such an underestimate. Also, phorate, another major organophosphate, requires less petroleum than diazinon. Since diazinon was taken as the representative organophosphate, if phorate were the substitute, petroleum use would be less than estimated here.

5. The mode of application was assumed similar for the substitute, i.e., soil incorporation and spraying (see Assumption 11 on following page). Amounts are from entomologists' recommendations published in Report No. 68-01-2448(6), RvR Consultants.

   Based on active ingredient:

   Diazinon -- 1.3 lb/lb heptachlor; 0.65 lb/lb chlordane.

   Carbaryl -- 1.0 lb/lb heptachlor; 0.5 lb/lb chlordane.

   Carbofuran -- 0.5 lb/lb heptachlor; 0.25 lb/lb chlordane.

6. It was assumed that each insecticide is applied one time per season, with no fuel cost to apply (for example, no tractor fuel). Thus, only manufacturing energy impact was calculated.

7. Cyclopentadiene, phenol, naphthol, and ethanol, which are feedstock materials for chlordane-heptachlor, carbofuran, carbaryl, and diazinon, respectively, may be produced in large quantities from coal. Only the petroleum source was considered, however.

8. The "total substitute" impact in the tables was calculated taking diazinon (a typical organophosphate), carbofuran, and carbaryl in the ratio 7:7:1. It was chosen after consulting with economists, and taking into account use patterns given in Project Reports #P4-01-03990, 14 Nov. 1974 (T. Reideburg Assocs.) and # 68-01-2448(6) (RvR Consultants).

9. The following conversion factors were taken from Chapter 9 of "Chemical Engineers' Handbook", by J.H. Perry, McGraw-Hill, 1963: coal 13,000 btu/lb; oil 140,000 btu/gal; 7 lb/gal, 42 gal/bbl, 294 lb/bbl; boiler heat 11,500 btu/kWh, 1100 fuel btu/lb steam.

10. Process solvent consumption was ignored. Rather, recovery was assumed. A quick calculation assuming 5% loss of benzene-like

solvent gave an increase in "Petroleum for feed and inerts", "Total substitutes" of 10% for chlordane, and 20% for heptachlor.

11. "Petroleum for inerts" was calculated assuming granular and wettable powder forms, except diazinon, contain no petroleum inerts.

The inerts were weighted as follows, based on estimated patterns supplied by Illinois Agr. Extension: chlordane, heptachlor, carbofuran, and carbaryl -- negligible. Diazinon AG500 (46$ inert) x 100% use = 46% inerts.

12. The effect on natural gas consumption was not considered. Natural gas was assumed to be of secondary importance as an industrial energy source. To convert coal in the tables to natural gas, assume 12.5 cu ft of gas per lb coal.

Remark: It is assumed that all other petroleum and energy-saving measures with higher benefit/cost indices have been taken. Energy expense in exchange for decreased human hazard is to be balanced against alternative uses for the same energy.

Further, it is assumed that patterns of crop cultivation and transportation, and attendant energy use, will not change as an economic consequence cancellation.

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